9.0 WATER & HYDROGEOLOGY

9.1 INTRODUCTION

This chapter of the EIAR assesses the impact on the hydrogeological and hydrological environments of the proposed development. The objectives are to provide a review of baseline conditions across the footprint of the site, to assess the potential impact of the proposed development on the hydrological and hydrogeological environments and to provide appropriate mitigation measures for any identified potential impacts, if deemed necessary.

The chapter was written by Niall Mitchell BE, CEng, MIEI, MSc, PGeo. Niall is a professional Hydrogeologist and Chartered Engineer with over 20 years' experience in the area of hydrogeological investigations and assessments, contaminated land investigations, risk assessment and remediation design and validation. He has an honours Civil Engineering degree from NUI, Galway, a Masters degree in Environmental Engineering from Trinity College and a Masters degree in Applied Hydrogeology from Newcastle University. Niall has been involved with high profile projects across the island of Ireland providing hydrogeological and contamination expertise for Environmental Impact Assessments, brownfield/fuel spill/chemical spill site investigations, risk assessments and remediation design. Example projects have included the Corrib Gas Terminal Site, (Co. Mayo), Titanic Quarter Redevelopment (Belfast), Barrow Street Gasholder Site (Dublin), Poolbeg Incinerator Project (Dublin) and Haulbowline Naval Base (Co. Cork). Niall has also provided expertise at Oral Hearing.

9.2 STUDY METHODOLOGY

The assessment was undertaken by undertaking the following:

- A desktop study of soils, subsoils and bedrock;
- A review of existing monitoring/site investigation data;
- A desktop review of sensitive receptors in the area; and,
- Interpretation of all data and reporting.

A number of site investigations were undertaken across the site – see Section 9.3.17. The soils and geological information in the borehole logs has been referred to in this chapter and in Chapter 8, and associated appendices, of this EIAR.

The following sources of information were used in the compilation of this assessment:

- Ordnance Survey of Ireland, Discovery Series, Sheet 55;
- Ordnance Survey of Ireland (OSI) online historical maps and aerial photographs;
- Geology of Kildare-Wicklow, Geological Survey of Ireland (GSI) (1:100,000), Sheet 16;
- GSI On-line Groundwater Database. Aquifer Classification, Aquifer Vulnerability;
- GSI Curragh West Groundwater body (GWB);
- Soil Map of Ireland (Second Edition, 1980), National Soil Survey of Ireland, An Foras Talúntais.
- National Parks and Wildlife Service on-line database www.npws.ie;
- EPA online water quality mapping; http://www.epa.ie/rivermap/;
- OPW hydro-data (http://www.opw.ie/hydro-data);
- Met Eireann - met.ie – monthly climatological data;
- Kildare County Council online planning files and County Development Plan;
- Consultations with Trinity College Dublin (TCD) Civil & Environmental Engineering Dept in relation to monitoring and assessments of Pollardstown Fen;

- White Young Green (2002). Curragh Aquifer - Current Conceptual Understanding and Numerical Modelling;
- Wright (1988) The Mid-Kildare Sand/Gravel Aquifer. Geological Survey of Ireland.
- Landslides in Ireland. G.S.I. Irish Landslides Working Group (2006); and,
- Directory of Active Quarries, Pits and Mines in Ireland (3rd Edition) G.S.I. 2002;

This chapter was undertaken in accordance with the following:

- Guidelines on the Information to be contained in Environmental Impact Assessment reports (Draft) August 2017,
- Geology in Environmental Impact Statements a Guide, (IGI, 2002),
- Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes, NRA Document.
- Guidelines for the preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements (IGI, 2013),
- Institute of Geologists Ireland (2002): Geology in Environmental Impact Statements – A Guide.
- Draft EPA revised Guidelines on information to be contained in Environmental Impact Statements; and Advice Notes for preparing EIS, 2015.

9.3 RECEIVING ENVIRONMENT

9.3.1 Site Location and Context

The site is located approximately 500 metres to the east of Kildare town core, north of Hospital Street.

The former Magee Barracks site currently consists of a number of vacant military buildings, all of which are in serious disrepair, areas of hard surfacing formerly used as training grounds / assembly areas and underutilised green-field lands.

Surrounding land uses include residential housing developments to the north, east and west with a number of retail / commercial land uses to the south of the site, along Hospital Street. The commercial uses include 2 no. car showrooms, a supermarket, a petrol station, a resource centre, a pharmacy and a primary care centre.

The proposed development comprises the first phase of the overall development of the applicant's c. 20.78 ha landholding at this location. The planning application is accompanied by an overall site masterplan drawing indicating future phases on the remainder of the lands, which include a permitted supermarket, a proposed cancer treatment clinic (proton therapy) (on appeal to ABP), and a Phase 2 residential development of c. 250 units.

9.3.2 Subsoils and Bedrock

The bedrock geology beneath Kildare town consists of Carboniferous limestone deposits. According to GSI sheet 16, "Geology of Kildare-Carlow" (McConnell, 1994) land subsidence, which occurred during the Carboniferous period in the Upper Palaeozoic, led to extensive ingress of seawater into the low lying areas which led to an accumulation of marine sediment deposits comprising intertidal laminated mud and sand. The type of sediment being accumulated was governed by the depth of the sea in a given location, and therefore progressive subsidence resulted in shallow water sediments to be deposited below the deep water marine sediments.

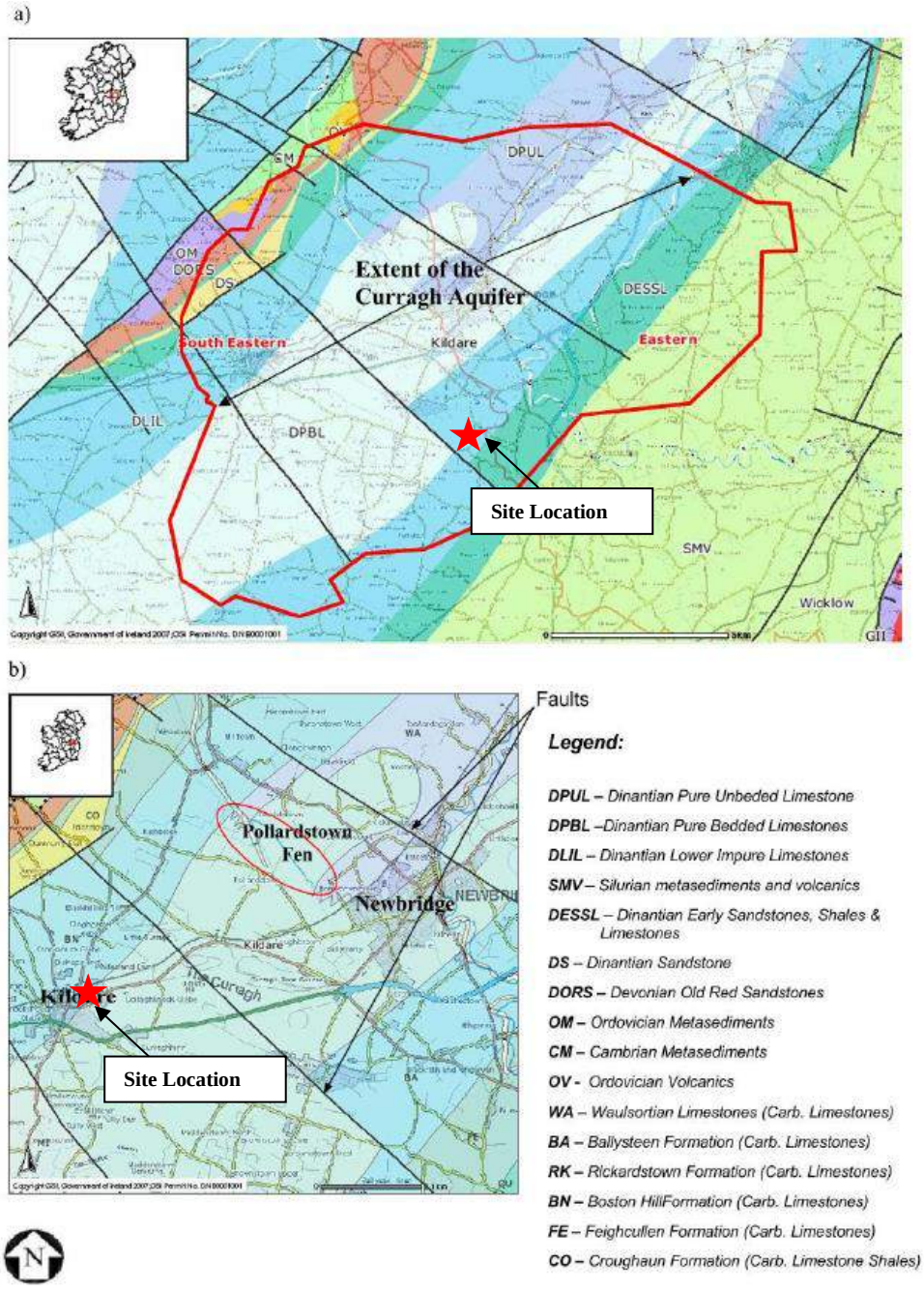
According to GSI sheet 16, the main rock units underlying the study area is the Rickardstown Formation (RK). The Rickardstown Limestone is cherty and often dolomitised. The GSI have identified two distinct

horizons within this formation. The lower horizon is varied and includes thin interbedded units of nodular crinoidal, cherty micrite and fossilferous shale. The upper part consists primarily of quite uniform, moderately dark grey, fine grained dolomite with abundant chert.

Other formations in proximity to the site include the Boston Hill Formation which includes major units of very distinctive, laminated limestone, which distinguish this formation from the Ballysteen Formation (see Figure 9.1).

The area surrounding Kildare town is cut with faults running predominantly in northwest-southeast direction. The site lies between two of these faults, one located approximately 1.55 km southwest and the other approximately 2.5 km northeast of the site. Pollardstown Fen is located a similar distance northeast of the northeastern fault line mentioned above. Appendix 9.1 contains an extract of the NPWS Site Synopsis for Pollardstown Fen SAC

No bedrock outcrops or karst features have been mapped across or in the vicinity of the site. The EPA soils map indicates the predominant soil type in the development area to be made ground.



Source: www.gsi.ie (Taken from Kuczynska, 2008).

Figure 9.1: Bedrock geology map of the area surrounding (a) the Curragh Aquifer; and (b) Pollardstown Fen.

9.3.3 Regional Aquifer Classification

The Geological Survey of Ireland has devised a system for classifying the aquifers in Ireland based on the hydrogeological characteristics, size and productivity of the groundwater resource into the National Draft Bedrock Aquifer Map. The three main classifications are Regionally Important Aquifers, Locally Important Aquifers, and Poor Aquifers. Each of these types of aquifer is further subdivided and has a specific range of criteria associated with it, such as the transmissivity (m^2/day), productivity, yield, and the potential for springs.

The site is underlain by the Regionally Important (Rg) Curragh Gravel Aquifer West Groundwater Body (GWB). This aquifer lies in a shallow trough, oriented NE-SW, at the surface of the limestone bedrock. The topography of the bedrock surface primarily controls the depth of this aquifer with the areas of greatest thickness to the northeast along the drainage divide where it can be up to 70 metres in thickness with reduced thickness away from this area of higher elevation.

The GWB is recharged from rainwater percolating through the topsoil and unsaturated sand and gravel deposits. The main discharge mechanisms present are baseflow discharge to rivers, seepages at the extremities of the body and discharge via springs. Where the water table is sufficiently close to the surface such that the riverbed elevation is lower than it is, the aquifer will contribute groundwater to the river. The occurrence of springs in a gravel aquifer is unusual, as these are more commonly associated with Karstic aquifers. It is considered that the discharges from such areas were initial small seepages, which were then altered by man to increase the flow. Natural processes can also lead to the convergence of flow at these springs.

The interaction between groundwater and surface water is complex and the quantification of the volume of groundwater that contributes to surface water flow and its chemical composition is often difficult to calculate. Groundwater contributions to surface water flow vary; however in the more productive aquifers such as the sand and gravel aquifer of this GWB, the contribution may be up to 80 or 90 percent (Toner et al., 2005).

The GWB is a feeder for the Grand Canal and an important source of baseflow for the major river catchments in Kildare, namely the Liffey, the Barrow and the Boyne. This is supported by the estimated flow from the aquifer to the Milltown Feeder at Pollardstown Fen, which is approximately 25,000 m^3/day.

The Curragh GWB has a large catchment area. Its hydrogeology is significant as it is an important source of baseflow for rivers and streams, it influences the ecology of a number of interesting habitats and it is the source of water for Pollardstown Fen. In terms of groundwater body classifications for the Water Framework Directive (WFD), a separate groundwater body has been delineated by the GSI within the Curragh GWB for Pollardstown Fen (see Figure 9.2).

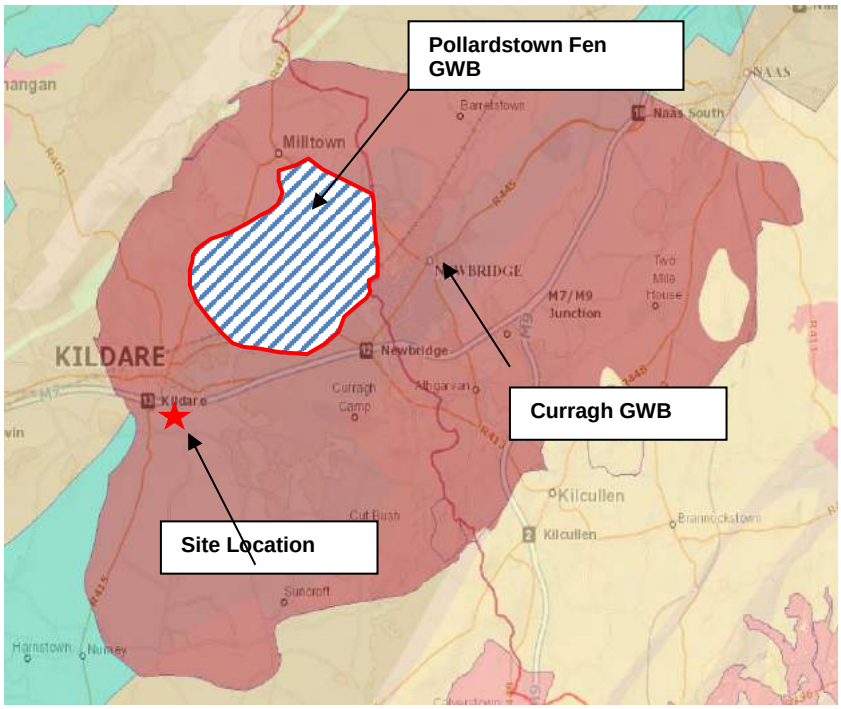


Figure 9.2: Curragh and Pollardstown Fen GWBs

The limestone bedrock aquifer underlying the gravel aquifer comprises a Regionally Important Aquifer – Karstified (diffuse) Rkd. Karstification and dolomitisation are two processes which strongly influence the development of secondary permeability and aquifer potential in Irish bedrock units. Karstification is the process whereby limestones are slowly dissolved away by acidic waters moving through them. This occurs most often in the upper bedrock layers and along some of the pre-existing fissures and fractures in the rocks which become slowly enlarged. This results in the progressive development of distinctive karst landforms such as collapses, caves, swallow holes, sinking streams, turloughs and dry valleys, and a distinctive groundwater flow regime where drainage is largely underground in dissolutionally enlarged fissures and conduits. The dissolution is influenced by factors such as: the type and solubility of the limestone; the degree of jointing, faulting and bedding; the chemical and physical character of the groundwater; the rate of water circulation; the geomorphic history (upland/lowland, sea level changes, etc.); and the subsoil cover. One of the consequences of karstification is the development of an uneven distribution of permeability which results from the enlargement of certain fissures at the expense of others and the concentration of water flow into these high permeability zones.

The Rkd classification of the bedrock aquifer represents those aquifers where flow is more diffuse with higher storage potential. These aquifers frequently have caves and large springs associated with them but the springs have more regular flow associated with them.

9.3.4 Characteristics and Properties of the Curragh Gravel Aquifer

The lateral variability of the aquifer substrates makes it difficult to quantify the aquifer properties. Aquifer mapping carried out by the GSI (Wright, 1988) and Glanville (1997) indicated that hydraulic conductivities in the western portion of the aquifer are lower than in the main body of the aquifer. Dewatering volumes encountered in the road cuttings appeared to support this, as volumes increased in the east of the cutting (Misstear *et al.*, 2008).

Pumping tests carried out by K.T. Cullen & Co. Ltd. (as reported by Misstear et al., 2008), to the southwest of Kildare Town indicated a transmissivity of 650 square metres/day where the aquifer was between 20 to 30 metres thick. This suggests permeabilities of between 22 to 33 metres/day for the

aquifer. Pumping tests carried out along the road cutting by Advanced Geotechnics Ltd. (AGL) indicated lower permeabilities of 5 to 21 metres/day. However, test conditions were not ideal, and no account was taken for partial penetration effects (Misstear *et al*., 2008a).

9.3.5 Characteristics of Pollardstown Fen

Pollardstown Fen is situated on the northern margin of the Curragh of Kildare, approximately 3km west north-west of Newbridge and 4.5 km northeast of Kildare town. It lies in a shallow depression, running in a north-west/south-east direction (see Figure 9.3). About 40 springs provide a continuous supply of water to the Fen, rising chiefly at its margins, along distinct seepage areas of mineral ground above the Fen level. The continual inflow of calcium-rich water from the south of the Fen, primarily from the Curragh, and from the limestone ground to the north, creates waterlogged conditions which lead to peat formation. There are layers of calcareous marl in this peat, reflecting inundation by calcium-rich water. This peat-marl deposit reaches some 6 m at its deepest point and is underlain by clay.

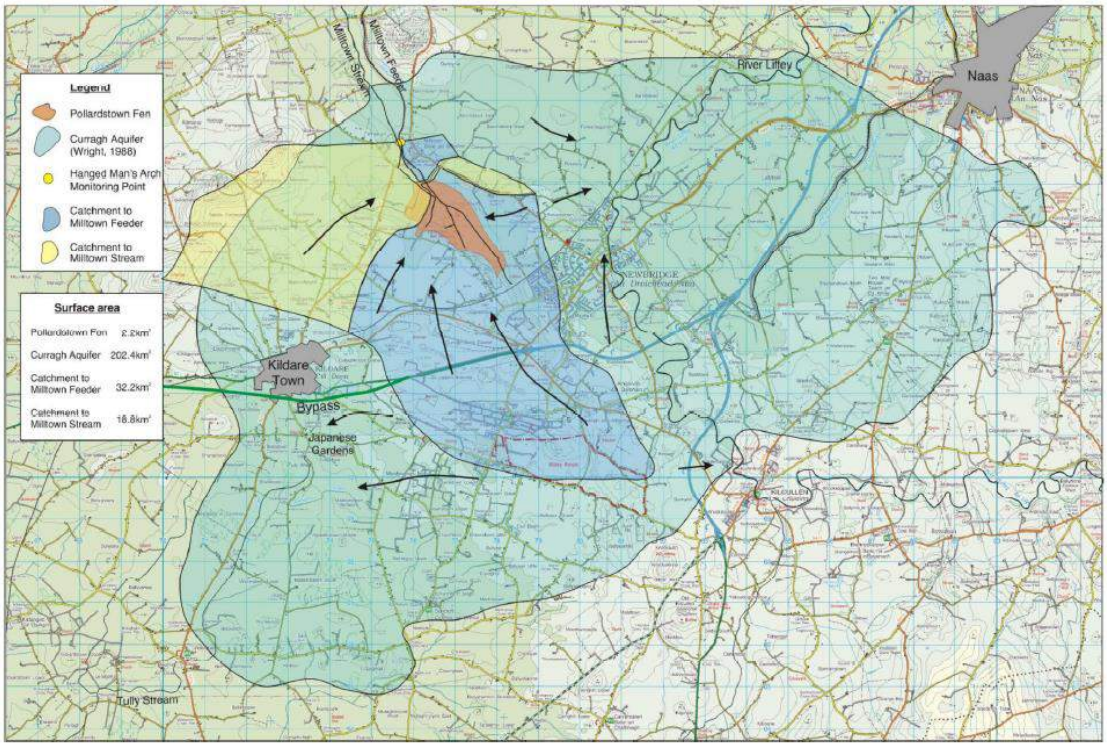
Pollardstown Fen is unusual in Ireland as it is an extensive area of primary and secondary Fen peat, lacking scrub vegetation on its surface. The vegetation is quite varied and species-rich with numerous well-defined plant communities and several rare or scarce floral species. Species and communities characteristic of more nutrient-rich conditions occur on the Fen margins where the water first emerges from the ground, while the central Fen area is dominated by more uniform and less nutrient-demanding vegetation types. Damp pastures occur on wet mineral soils and partly-drained peats on the Fen margins, which are reasonably species-rich, with particularly good displays of orchids in some areas.

The Fen has ornithological importance for both breeding and wintering birds. An area of reclaimed land was re-flooded in 1983 and has now reverted to open water, swamp and regenerating Fen. Since the re-flooding of the Fen and the development of the shallow lake, wintering waterfowl have been attracted in increased numbers.

Otter and Brook Lamprey (*Lampetra planeri*), two species listed in Annex II of the EU Habitats Directive, occur at Pollardstown. Various groups of the invertebrate fauna have been studied and the system has been shown to support a true Fen fauna. The species complexes represented are often rare in Ireland, with the sub-aquatic organisms particularly well represented. A number of internationally important invertebrates (mostly Order Diptera, i.e. two-winged flies) have been recorded from the site. Of particular conservation importance, however, is the occurrence of all three of the Whorl Snails (*Vertigo* spp.) that are listed on Annex II of the EU Habitats Directive. Pollardstown is the only known site in Ireland (or Europe) to support all three species (*Vertigo geyeri*, *V. angustior*, *V. moulinsiana*) (NPWS, 2003).

There are a number of drains cross cutting the Fen which discharge to the Milltown feeder. The Milltown Feeder joins the Grand Canal near Robertstown Co. Kildare, and it is the main source of water for the canal. Daly (1981) estimated that approximately 25,000m^3 per day was discharging through the Milltown feeder from the Fen. Approximately 92% of the discharge from the Fen emanates from the southern part of the catchment, while the remaining 8% is sourced from the smaller northern portion of the catchment, the spring at the public entrance to the Fen and direct precipitation (Kuczynska, 2008).

A schematic catchment map of the Curragh aquifer was historically prepared by Dr. Les Brown (Misstear *et al.*, 2008), which indicates groundwater flow direction and is presented in Figure 9.3 below. This map was prepared based on topography only and not groundwater head. As is evident from this map, groundwater flow direction in the vicinity of Kildare town is to the southwest,



Source (Missterar et al, 2008b)

Figure 9.3: Groundwater Flow Direction from Curragh Aquifer to Pollardstown Fen Pollardstown Fen GWBs

9.3.6 National Stud & Japanese Gardens

The National Stud and Japanese Gardens are located approximately 500 metres southeast of the entrance to the Magee Barracks site (see Figure 9.3). The Stud includes a series of ponds that are spring fed from the Curragh Aquifer and flow via a series of surface water features in a southwesterly direction across the site, through the Japanese Gardens, before discharging under the Tully Road and eventually into the Tully Stream.

Consultations with Mr. Paul Johnston (Trinity College Civil Engineering Department) confirmed the interpreted groundwater flow direction as detailed in the Phase 1 Hydrogeological Assessment. Mr. Johnston was heavily involved in research undertaken by Trinity College on the Curragh aquifer and Pollardstown Fen and the impacts of the Kildare Bypass on the hydrological and hydrogeological environment in the area. Mr Johnston highlighted that the Kildare Bypass/M7 Motorway appears to be acting as a control mechanism on groundwater and surface water levels in the general area to such an extent that water levels (both groundwater and surface water) to the south of the bypass have been notably impacted (i.e. have reduced over time). The road appears to be acting as a groundwater barrier or groundwater divide in the area.

Consultations with the National Stud facility manager (Mr. David Wordell) confirmed that water levels within the ponds at the facility have been significantly impacted upon by the construction of the Kildare Bypass, to such an extent, that a deep groundwater abstraction well was recently installed by the National Stud to augment water levels within the ponds on a permanent basis. This would confirm the findings of Trinity College in relation to the impact of the bypass on regional groundwater flows.

Based on the above and the location of the Japanese Garden relative to the Magee Barracks site i.e. not being downgradient) confirms that the Japanese gardens in addition to the Tully River are not at risk from the proposed development.

9.3.7 Regional Aquifer Vulnerability

The GSI classify aquifer vulnerability as the intrinsic geological and hydrogeological characteristics that determine the ease with which groundwater may be contaminated by human activities. The vulnerability of groundwater depends on the ability of contaminants to migrate to the underlying aquifer which is dependant predominantly on the permeability and thickness of the subsoils overlying the groundwater body and the types of recharge source (i.e. diffuse or point source) – see Table 9.1. Under the GSI groundwater vulnerability classification scheme the mapped vulnerability at a location applies to the shallowest groundwater target (i.e. aquifer) at the location.

A groundwater vulnerability map is provided in Figure 9.4 and outlines the GSI aquifer vulnerability mapping for the area in the vicinity of the site.

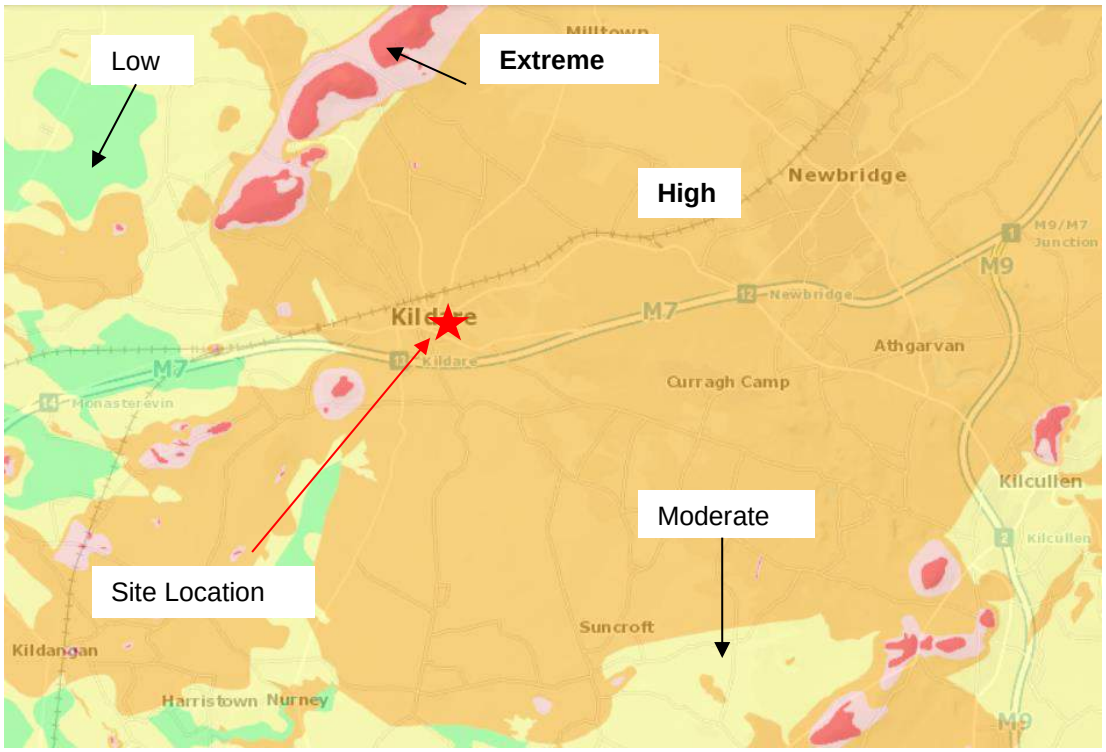


Figure 9.4: Groundwater Vulnerability Mapping

Vulnerability Rating	Hydrogeological Conditions				
	Subsoil Permeability (Type) and Thickness			Unsaturated Zone	Karst Features
	High Permeability (sand/gravel)	Moderate permeability (*e.g.* Sandy subsoil)	Low permeability (*e.g.* Clayey subsoil, clay, peat)	(Sand/gravel aquifers only)	(<30m radius)
Extreme (E)	0 – 3.0m	0 – 3.0m	0 – 3.0m	0 – 3.0m	-
High (H)	> 3.0m	3.0 – 10.0m	3.0 – 5.0m	> 3.0m	N/A
Moderate (M)	N/A	> 10.0m	5.0 – 10.0m	N/A	N/A
Low (L)	N/A	N/A	> 10.0m	N/A	N/A
Notes: (1) N/A = not applicable (2) Precise permeability values cannot be given at present. (3) Release point of contaminants is assumed to be 1-2m below groundwater surface					

Table 9.1: Vulnerability mapping criteria (adapted from DELG/EPA/GSI, 1999)

Aquifer vulnerability is largely dependent on overburden thickness and the inherent permeability of the bedrock. If bedrock is near or exposed at the surface the groundwater classification will be extreme. A detailed description of the groundwater vulnerability categories can be found in the Groundwater Protection Schemes document (DELG/EPA/GSI, 1999) and in the draft GSI Guidelines for Assessment and Mapping of Groundwater Vulnerability to Contamination (Fitzsimons et al, 2003). According to the GSI the vulnerability classification for the site is High (H) likely based on the presence of high permeability sand and gravel subsoils.

9.3.7 Groundwater Water Framework Directive Status

Work completed for the Water Framework Directive has recently assigned 'Status' to surface waters and groundwater (www.wfdireland.ie - watermaps). The Water Framework Directive status of the Curragh ground water body, which is linked to Pollardstown Fen SAC, is rated as poor (Figure 2).

The GSI database indicates that the poor status is largely due to abstraction and drainage pressures rather than water quality issues. The South Eastern Regional Basin District (SERBD) Groundwater-Action-Plan-March-2010 also states that Pollardstown Fen and The Curragh GWB are in poor status due to drainage pressures (SERBD).

However, as the Curragh GWB is a gravel aquifer, it is highly vulnerable. Therefore, discharges to the ground may give rise to impacts to the ground water body and the habitats and species that rely on ground water. A summary of E.U. Annex II Habitats and EU Annex IV Species sensitivity to changes in groundwater is provided in Appendix 9.2.

The Water Framework Directive (WFD) groundwater body interim assessment summary (www.watermaps.ie) for the South Eastern RBD (2005) shows that the Curragh GWB is 'probably not at significant risk'; however the Pollardstown Fen GWB is 'probably at significant risk'.

The majority of sediments within this aquifer are Calcareous with groundwater quality indicating a hard to very hard water. Average electrical conductivity in this area is 665 µS/cm, which is considered high.

Groundwater quality and quantity must be protected in their own right under the requirements of the WFD (2000/60/EC). The Groundwater Directive (80/68/EEC) and the WFD are the relevant pieces of EU legislation relating specifically to groundwater. The current standards related to groundwater in Irish legislation are the environmental quality standards set for Schedule 1 and Schedule 2 substances in the water pollution regulations (S.I. 271 of 1992) and the Groundwater Regulations 2010.

Kildare County Council has no available monitoring results for the groundwater body immediately underlying the former Magee Barracks site, as there are no monitoring wells in place and sampling points are not readily available.

In terms of groundwater body classification for the WFD, a separate groundwater body has been delineated within the Curragh GWB for Pollardstown Fen, as shown in Figure 9.2. In terms of groundwater dependant terrestrial ecosystems, two in the SERBD (Pollardstown Fen and the Curragh GWB) are classified as 'Poor Status' due to drainage pressures.

9.3.8 Groundwater Recharge

The GSI has published Groundwater Recharge Mapping for almost all of Ireland. Potential or effective rainfall is the amount of rainfall that is available to infiltrate the ground and that will not evaporate or be taken up by plants. The effective rainfall for the area is 491 mm/yr.

This effective rainfall rate influences the amount of recharge the study area receives and will influence the groundwater throughput beneath the study area.

Actual recharge is the measure of how much rainfall can actually be assumed to infiltrate the ground and recharge the water table. It is based on the potential rainfall but also takes into account rainwater that does not enter the ground but becomes overland flow and enters streams. This occurs when the soil is saturated or has reached its field capacity, which is common in Ireland.

9.3.10 GSI Well Database

The GSI online map identifies the following list of all wells within 1 km of the site as detailed in Table 9.2 below:

Easting	Northing	Well Type	Depth	Depth to Rock	Well Use	Yield (m^3/d)
273460	210860	Dug Well	2.7	Unknown	Unknown	27.28
274330	212890	Unknown	13.4	Unknown	Unknown	Unknown
274750	213090	Borehole	30.5	Unknown	Unknown	Unknown
274760	212650	Dug well	5.8	Unknown	Unknown	Unknown
274810	212400	Borehole	16.2	Unknown	Unknown	Unknown
274680	212240	Dug well	4	Unknown	Unknown	Unknown
274600	212100	Borehole	15	Unknown	Unknown	Unknown
274340	211830	Borehole	13.5	Unknown	Unknown	Unknown
274290	211820	Borehole	13.5	Unknown	Unknown	2,964
274230	211810	Borehole	10	Unknown	Unknown	Unknown
273780	211400	Borehole	11.6	Unknown	Unknown	Unknown
273960	212990	Borehole	56.6	48.8	Unknown	2,182
274230	213080	Dug well	14.8	Unknown	Unknown	Unknown

Table 9.2 Groundwater wells within 1 km

9.3.11 EPA/GSI Source Protection Zones

As reported by the EPA and GSI, groundwater sources, particularly public, group scheme and industrial supplies, are of critical importance in many regions. Consequently, the objective of source protection zones is to provide protection by placing tighter controls on activities within all or part of the zone of contribution (ZOC) of the source.

There are two main elements to source protection land surface zoning:

- Areas surrounding individual groundwater sources; these are termed source protection areas (SPAs)
- Division of the SPAs on the basis of the vulnerability of the underlying groundwater to contamination.

These elements are integrated to give the source protection zones. Two source protection areas are recommended for delineation:

- Inner Protection Zone (IPA). This area is designed to protect against the effects of human activities that might have an immediate effect on the source and, in particular, against microbial pollution. The area is defined by a 100-day time of travel (TOT) from any point below the water table to the source. In karst areas, it will not usually be feasible to delineate 100-day TOT boundaries, as there are large variations in permeability, high flow velocities and a low level of predictability. In these areas, the total catchment area of the source will frequently be classed as SI;
- Outer Protection Zone (OPZ), encompassing the remainder of the groundwater source catchment area or Zone of Contribution (ZOC). It is defined as the area needed to support an abstraction from long-term groundwater recharge i.e. the proportion of effective rainfall that infiltrates to the water table.

There are no source protection areas within 3km of the site. Two public water supply (PWS) schemes are mapped by the GSI as follows (see Figure 9.5):

- Curragh Camp PWS – Area of 0.13 km^2 – (Code IE_SE_G_133) – located within the Curragh Gavel West GWB – The former barracks site is located approximately 3.4 km northwest of the outer extent of the closest Inner Protection Zone (IPZ) of the supply.
- Monasterevin/Rathangan PWS – Area of 2.92 km^2 – Code (IE_SE_G_153) – located within the Bagenalstown Upper GWB – The former barracks site is located approximately 4.2 km southeast of outer extent of the Outer Protection Zone (OPZ) and greater than 6 km southeast of the closest part of the IPZ of the supply.

No karst features have been identified within 10km of the site.

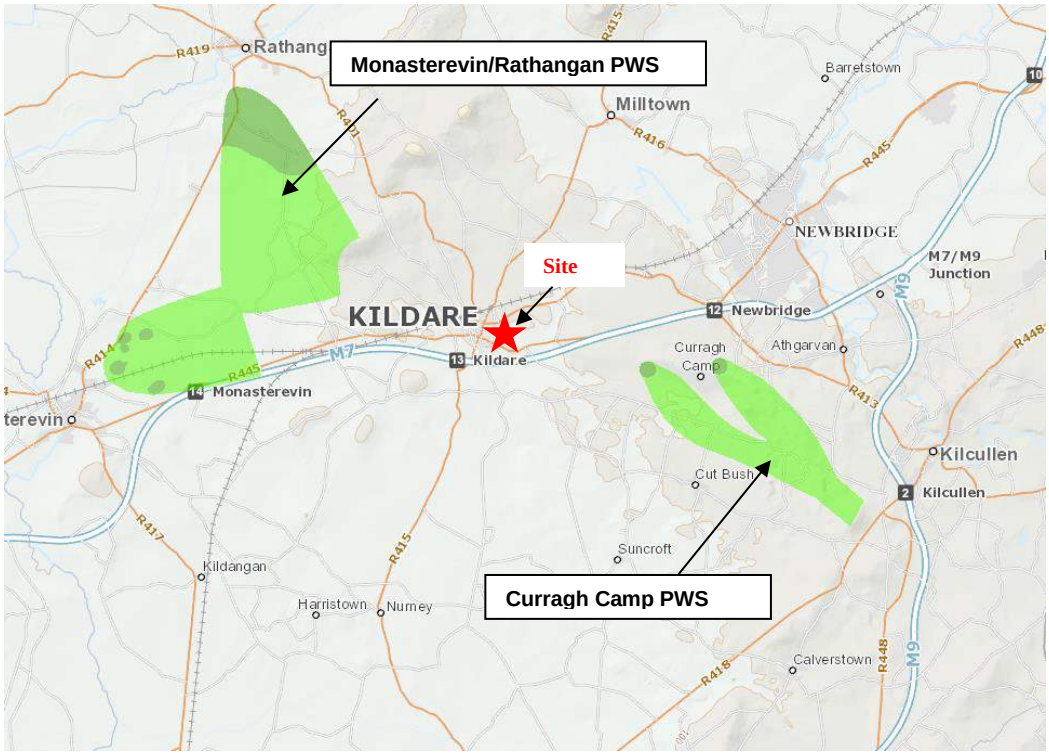


Figure 9.5 Identified Source Protection Zones

9.3.12 Hydrology

The majority of the site is located in the South Eastern River Basin District (SERBD) in the Barrow catchments (Code: IE14_01) (www.epa.ie).

There are no mapped streams/rivers in the vicinity of the site. The Cloncumber Stream that flows into the Slate River in a northeasterly direction is located approximately 5km northeast of the site to the northeast of Pollardstown Fen. The Tully stream, located 2.5 km to the south of the site, flows in a southwesterly direction and ultimately into the River Barrow. These surface water features are not considered at direct risk from the proposed development although it is anticipated that at least one of these features is contributed to by groundwater baseflow.

9.3.13 Flood Risk

A flood risk assessment was undertaken for the site by Garlands and accompanies this application. The assessment concluded that based on all information reviewed relating to flood risk, the site is located within a Flood Zone C (low risk) for all sources of flood risk (i.e. fluvial flood risk, pluvial/storm water flood risk and groundwater flood risk).

9.3.14 Groundwater levels, Flow Directions and Gradients

The Curragh gravel aquifer has intergranular primary porosity. Variability in the aquifer material influences the hydrogeological behaviour of the aquifer. The aquifer is reportedly unconfined across most of the GWB. Groundwater gradients are estimated from the water table contours produced by Wright (1988) to be in the order of 0.002.

The Mid-Kildare aquifer is a feeder for the Grand Canal and is an important source of baseflow for the streams and rivers. This is supported by the estimated flow from the aquifer to the Milltown Feeder at Pollardstown Fen of approximately 25,000 m^3/day (Daly, D. 1981). It is also supported by high specific dry weather flow for the Tully Stream which is calculated as 3.9 l/sec/km^2 (figures in excess of 2 l/sec/km^2 are considered to indicate significant baseflow). The aquifer provides baseflow for the major river catchments in Kildare, namely the Liffey, the Barrow and the Boyne. Pollardstown Fen, and important natural heritage site, also derives its water from the aquifer.

Regional groundwater flow directions estimated by Wright (1988) and Misstear (2008b) are outlined in Figure 9.3 based on topographical relief only. However, more recent and detailed groundwater level mapping was undertaken by Mr. Richard Langford in 2011 in conjunction with Trinity College, Dublin that involved the recording and application of accurate water levels.

Groundwater monitoring was undertaken by Langford, 2011 at a local scale for intensive monitoring of water levels at the Fen margin and at a regional scale for intensive monitoring of the groundwater flow regime across the Curragh Aquifer. The groundwater monitoring network (27 no. monitoring boreholes in total) had been set up previously by WYG and Kildare County Council as part of the monitoring programme established during the construction of the Kildare town by-pass. Monthly groundwater levels were recorded manually from June 2010 to July 2011. Historical groundwater head data from 1997 to 2008 was also assessed by Langford, 2011, which was provided by TCD and WYG Ltd.

The assessment, which is considered to be more representative and accurate than Figure 9.3 and based on actual groundwater heads within numerous monitoring wells across a significant area, confirms that regional groundwater flow direction immediately south of Pollardstown Fen to be generally in a northeasterly direction towards the Fen. However a groundwater divide was confirmed and mapped to the northeast of Kildare town. South of this divide, groundwater is interpreted to flow in a southwesterly

direction across Kildare town. The proposed development is located southwest of this divide and therefore groundwater is interpreted to flow locally in a southwesterly direction across the site and not towards Pollardstown Fen. This is consistent with the interpreted flows by Misstear *et al.*, 2008 (as detailed in Section 9.3.5).

The monitoring borehole locations utilised by Langford, 2011 are presented in Figure 9.6 and Figure 9.8 with a cross section of the aquifer and interpreted ground flow directions provided in Figure 9.7 and Figure 9.8. In addition, the catchment of Pollardstown Fen was reassessed by Langford, 2011, and the former Magee Barracks was confirmed to be located southwest of the catchment boundary of the fen (see Figure 9.8).

As discussed in Section 9.3.6, it was confirmed that the Kildare Bypass/M7 Motorway appears to be acting as a control mechanism on groundwater and surface water levels in the general area to such an extent that water levels (both groundwater and surface water) to the south of the bypass have been notably impacted (i.e. have reduced over time). The road appears to be acting as a groundwater barrier or groundwater divide in the area that is locally impacting on water levels and flow directions.

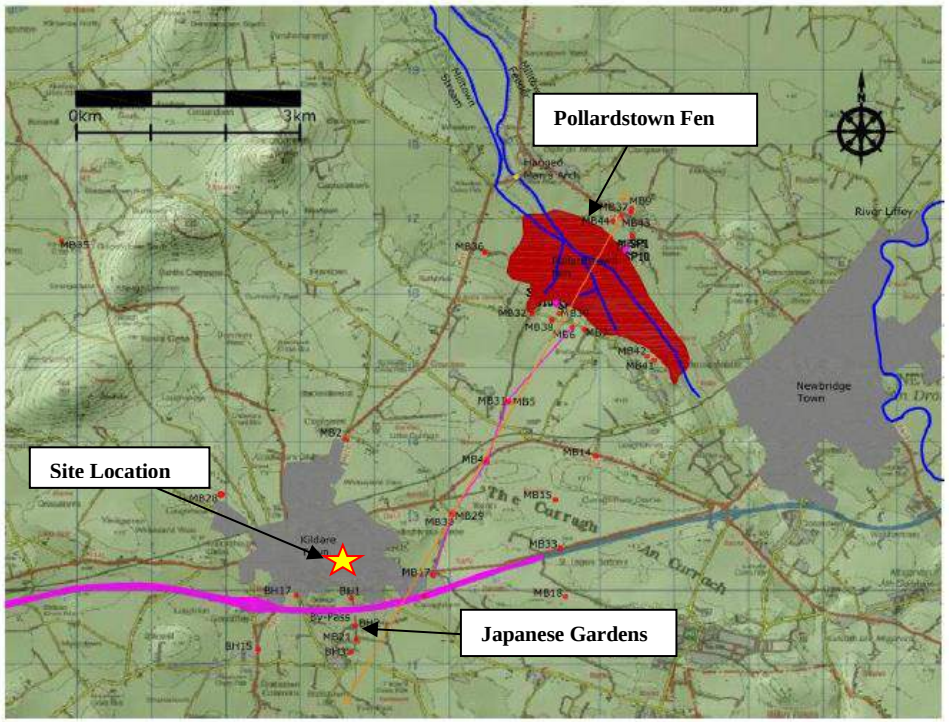


Figure 9.6: Transect through Curragh Aquifer & Pollardstown Fen

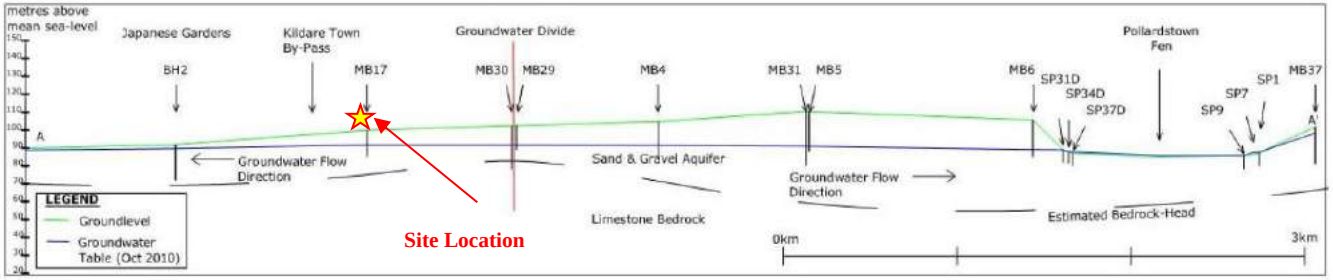


Figure 9.7: Section through Curragh Aquifer & Pollardstown Fen showing depths to water level and groundwater flow direction

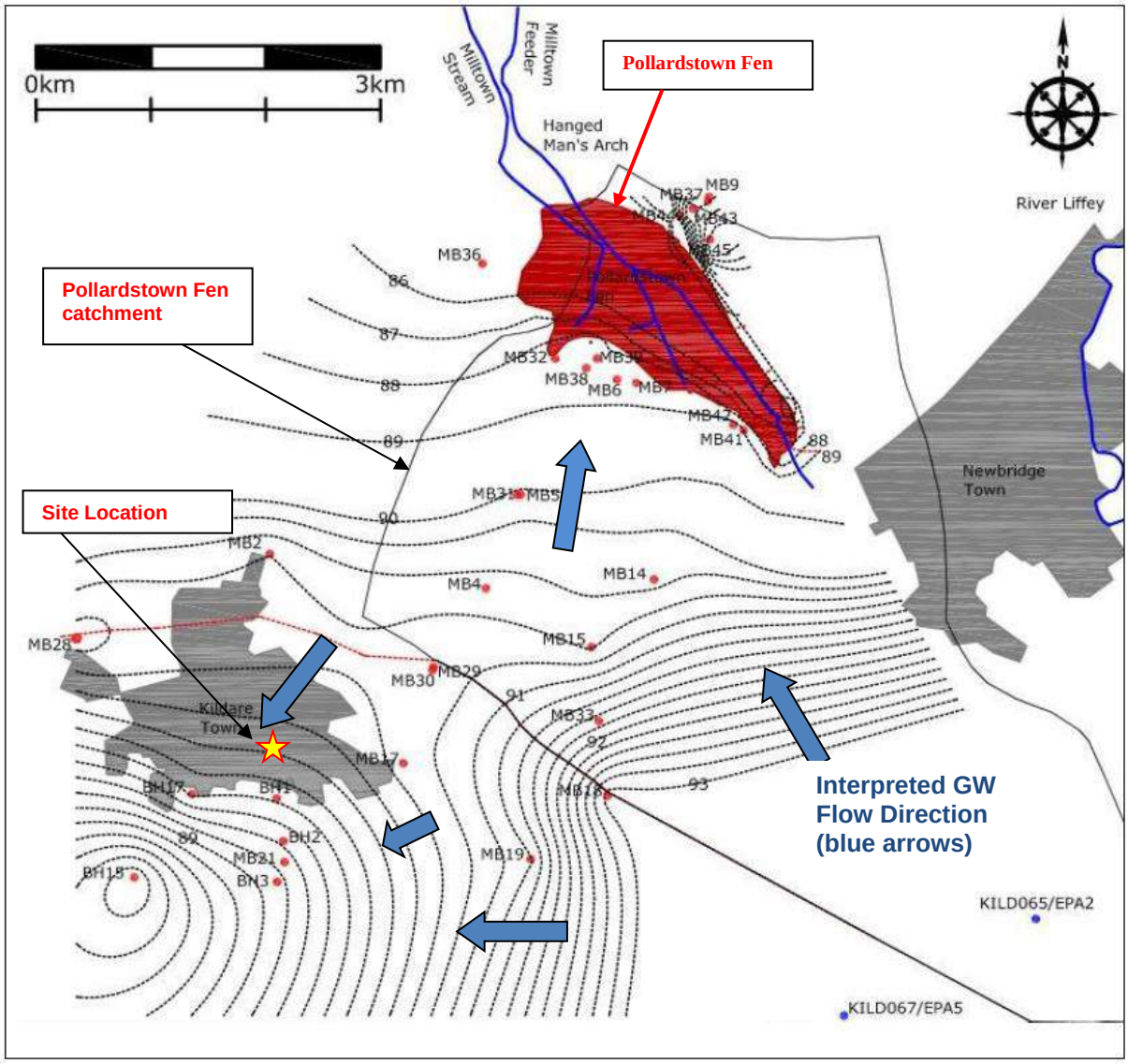


Figure 9.8: Interpreted Groundwater Contours (Curragh Aquifer) and Fen Catchment

9.3.15 Regional Groundwater Quality

Although there is no available information relating to groundwater underlying the proposed site, regional groundwater quality is known to be hard to very hard water (i.e. 250 - >350 mg/l) Average electrical conductivity in this area is 665 µS/cm, which is considered high.

9.3.16 Designated Protected Areas

The nearest site designated for nature conservation is the Curragh proposed Natural Heritage Area (pNHA), (site code 000392) approximately 0.5km to the northeast at its closest point. The Grand Canal pNHA (002104) is 5km to the north at its closest point.

The nearest Special Areas of Conservation (SAC) are Pollardstown Fen SAC (000396), 3.6km to the north east, the River Barrow and River Nore SAC (002162), 7km to the south and Mouds Bog SAC (002331), 7km to the north east. Ballynafagh Lake SAC (001387) and Ballynafagh Bog SAC (000391) are 15km to the north east. The locations of designated sites are shown in Figure 9.9 below.

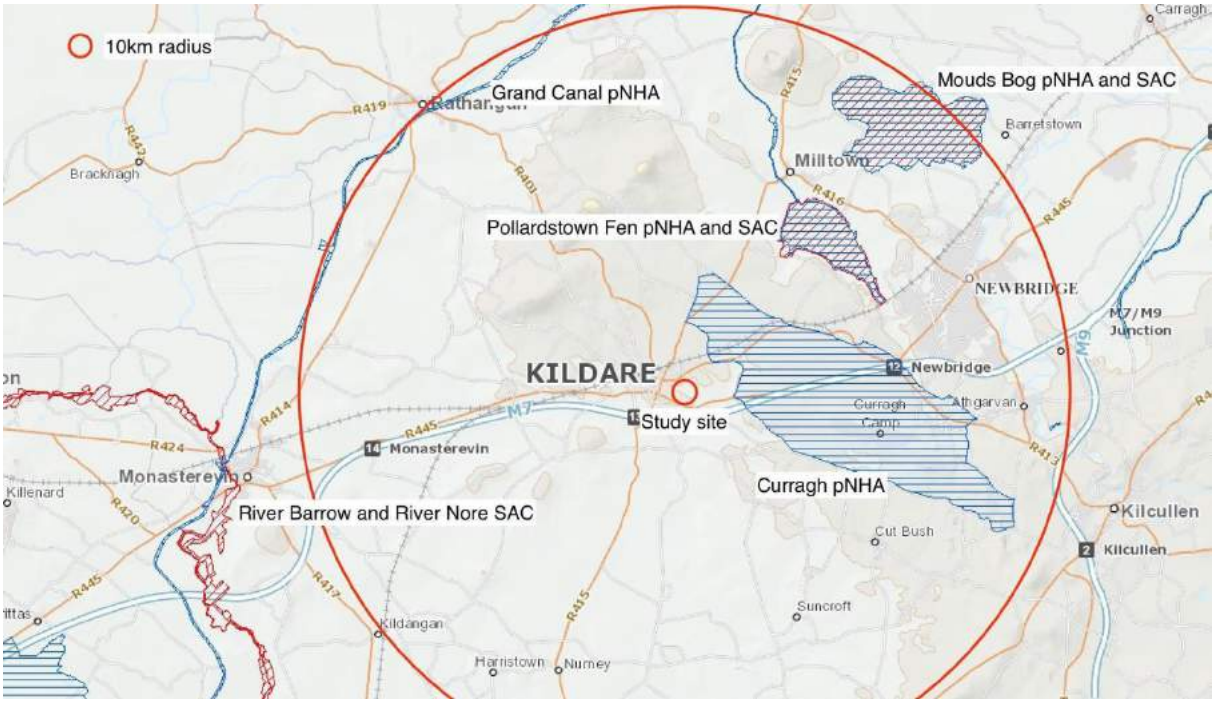


Figure 9.9: Designated Sites (European Sites and non-European Sites) Map

9.3.17 Previous Site Investigations

As detailed in Chapter 8, a number of site investigations were undertaken across the entire former Magee Barracks site Masterplan between 2016 and 2018. These include the following:

- Ground Investigations Limited - August 2016 – 10 no. trial pits and 10. no. infiltration tests within each trial pit.
- Site Investigations Limited – May 2017 – 15 no. cable percussive boreholes and 22 no. trial pits.
- Site Investigations Limited – February 2018 – 9 no. infiltration tests

Details of the site investigation results are provided in more detail in Chapter 8. All trial pits, boreholes and infiltration test locations are presented in Figures 9.10 and 9.11 respectively with the 2018 infiltration test locations presented in Figure 9.12.

A generalised summary of the ground profile encountered across the site is outlined below:

- **Made Ground** was described generally as brown slightly sandy gravelly clay with frequent cobbles containing occasional fragments of concrete, red brick, glass and plastic. With the exception of tarmac areas or areas with a thin layer of stone fill, made ground was detected across a wide area of the site i.e. within 21 of 37 no. investigation locations at depths greater than 0.25 metres. The depths of made ground were recorded up to 2.3 mbgl with an average depth of 1.0 metre being recorded. The material appears to be broadly representative of reworked soils with residual, historical and low levels of Construction and Demolition (C&D) waste material present within this horizon.
  Greater depths of made ground, up to 8.3 mbgl, were recorded in the southeast of the former barracks site outside the proposed development site boundary (i.e. boreholes BH13 and BH14). The material at these locations comprised similar type of made ground recorded elsewhere with increased quantities of brick, timber, glass and metal at much greater depths. The material description at this location suggests the material is former C&D material from the historical usage of Magee Barracks.

- **Cohesive Till Deposits** comprising brown slightly sandy slightly gravelly clay with occasional cobbles with a strength increasing from firm to stiff or stiff with depth was recorded up to 9.7 metres in places. These deposits had some, occasional or frequent cobble and boulder content where noted on the exploratory borehole logs.
- **Granular Till Deposits** comprising sand and gravel deposits were encountered across the site although not as a continuous body. The average thickness was 0.7 metres and the greatest thickness was recorded up to 4.3 metres within TP19 and TP20 in the southern region of the site. Deeper gravel deposits were encountered in the southeastern region of the site only and within the deepest borehole BH10. The gravel deposits encountered at this location were encountered between 9 and 15 mbgl and may be representative of the regional sand and gravel body that forms part of the Curragh gravel aquifer body. The gravel deposits encountered at shallower depths are considered unlikely to be part of this same gravel body given the presence of the low permeability clays underlying this shallow material and the detections of the material across the site.
- **Groundwater** strikes or seepages were not encountered in any of the boreholes or trial pits across the site, although it is acknowledged that no monitoring wells were installed within any of the boreholes to facilitate groundwater monitoring over time.
- 10 no. infiltration tests were undertaken within trial pits in 2016 and 9 no. tests in February 2018. A summary of the results is provided below in Table 9.3. The results indicate that significant areas of the site are not suitable for infiltration activities for soakaway design within the shallow cohesive subsoils. However infiltration testing within the deeper sand and gravels has not been undertaken to-date.

Date	Test ID	Result	Pass/Fail
2016	SA01	6.78×10^{-5}	Pass
	SA02	-	Fail – water dropped too slowly
	SA03	2.63×10^{-4}	Pass
	SA04	7.0×10^{-6}	Pass
	SA05	-	Fail – water dropped too slowly
	SA06	2.07×10^{-5}	Pass
	SA07	1.17×10^{-5}	Pass
	SA08	-	Fail – water dropped too slowly
	SA09	-	Fail – water dropped too slowly
	SA10	-	Fail – water dropped too slowly
2018	SA01	-	Fail – water dropped too slowly
	SA02	-	Fail – water dropped too slowly
	SA03	-	Fail – water dropped too slowly
	SA04	2.02×10^{-5}	Pass
	SA05	-	Fail – water dropped too slowly
	SA06	-	Fail – water dropped too slowly
	SA07	-	Fail – water dropped too slowly
	SA08	-	Fail – water dropped too slowly
	SA09	-	Fail – water dropped too slowly

Table 9.3: Infiltration Test Results

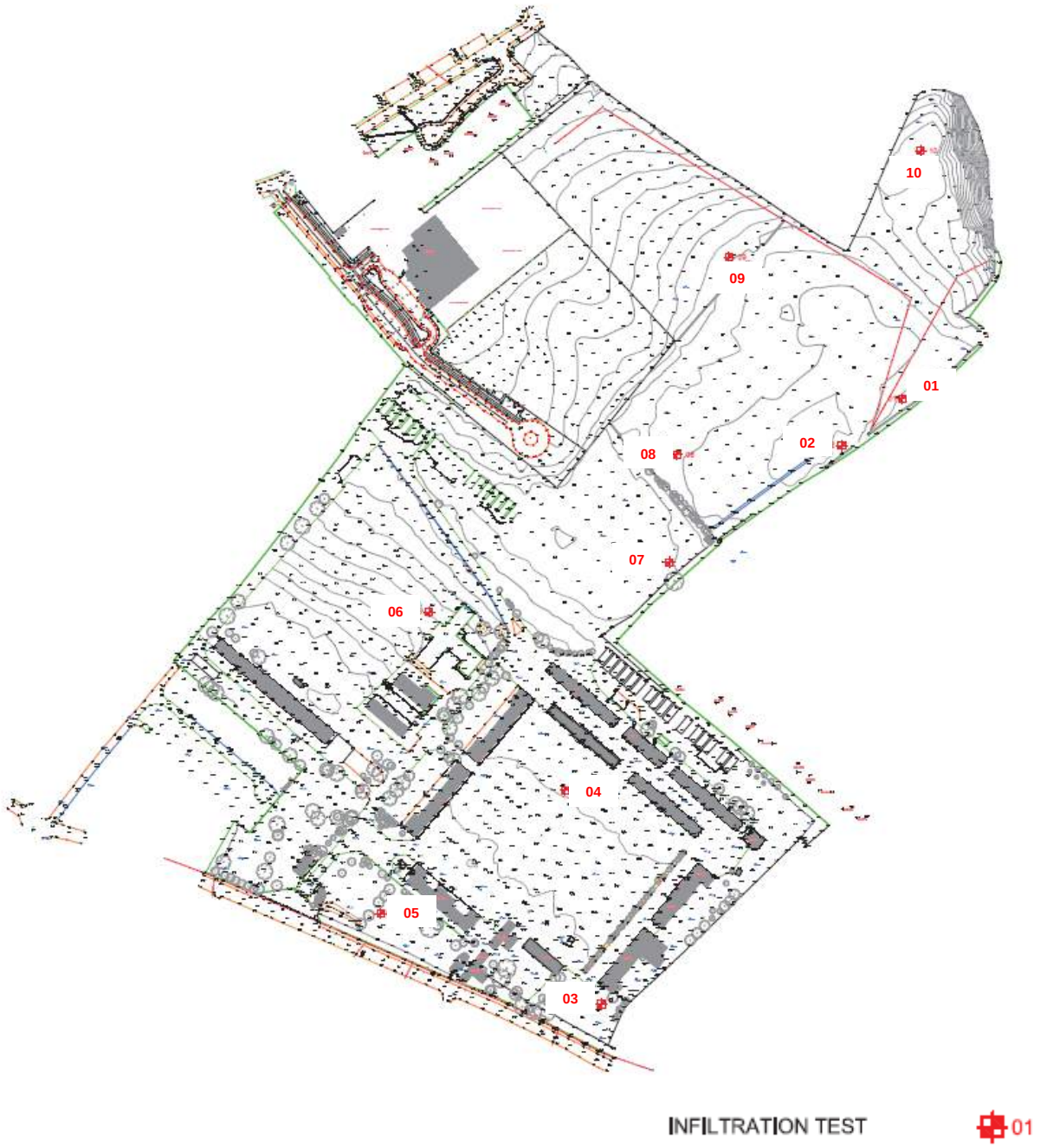


Figure 9.10: 2016 Site Investigation Locations in proximity to the Phase 1 site

Figure 9.11: 2017 Site Investigation Locations

Figure 9.12: 2018 Site Investigation Locations

9.4 CHARACTERISTICS OF THE PROPOSED DEVELOPMENT

'The development will consist of the demolition of 17 no. existing buildings (including a range of former Barracks buildings, the Officers' Mess building and Water Tower structure) with a GFA of 16,320 m^2, and the construction of a development comprising of 375 no. residential units, a neighbourhood centre comprising of 3 no. single-storey retail units with a GFA of 130 m^2, 105 m^2 and 100 m^2 respectively, a café (including gallery / exhibition area at mezzanine level) with a GFA of 300 m^2, a two-storey childcare facility with a GFA of 680 m^2 and associated play area, all internal roads, car parking, pedestrian and cycle paths, public open space, and all associated site and infrastructural works on an application site of c. 11.35 ha.

The 375 no. residential units proposed consist of the following:

- 76 no. 3 bed semi-detached units;
- 42 no. 3 bed terrace units;
- 60 no. 4 bed semi-detached units;
- 7 no. 4 bed detached units;
- 16 no. 1 bed apartment units within the duplex blocks;
- 34 no. 2 bed apartment units within the duplex blocks;
- 18 no. 3 bed apartment units within the duplex blocks;
- 30 no. 1 bed apartment units within the apartment blocks; and
- 92 no. 2 bed apartment units within the apartment blocks.

The houses are 2 to 3 storeys in height, the duplex blocks are 2 to 3 storeys in height and the apartment blocks are 4 to 5 storeys in height over basement car park. The associated site and infrastructural works include foul and surface / storm water drainage, attenuation tanks, 639 no. car parking spaces comprising, 560 no. spaces for the residential units, 51 no. visitor spaces and 28 no. spaces to serve

the proposed creche, retail, and café units, public open space measuring c. 1.80 hectares, bin and bike stores, 3 no. electricity substations, landscaping, boundary walls, railings and fences.

A new signalised road junction is proposed onto Hospital Street providing access to the proposed development and also to the adjacent lands where a supermarket and cancer treatment clinic are proposed. Road works are also proposed to Hospital Street (R445), including pedestrian crossings, provision of cycle lanes, upgrades to footpaths, signage, road markings and traffic signalling.

The proposed development comprises the first phase of the overall development of the applicant's c. 20.78 ha landholding at this location.

9.5 PROPOSED STORMWATER DRAINAGE

The surface water collection and infiltration system for the entire site has been designed in accordance with the Greater Dublin Strategic Drainage Study (GDSDS), the CIRIA SUDS Manual 2015 and Recommendations for Site Development Works for Housing Areas published by the Department of the Environment and Local Government – see Drainage Report prepared by Garland which accompanies this application.

Garland Engineers have proposed the following drainage system for the Phase 1 development which comprises a combination of storm water discharge to mains network and infiltration to ground system. A brief description of the proposed system is outlined below as provided by Garland Engineers:

- Storm water from all roofs and parking areas will discharge directly into permeable paving systems with stone below to provide quality control and some limited local storage. A permeable membrane is proposed to allow for maximum infiltration to ground. Should the sub soil present be saturated or insufficient to allow infiltration to ground, the system would act as a temporary "tank" and discharge to the internal surface water network until such time that infiltration is possible again. Outflows from permeable paving areas will be via "fin drains" and 110mm outfall pipes to the adjacent storm network. Attenuation up to the 100 year RP design storm event will be provided via underground soakaway systems, Wavin AquaCell infiltration units or similar approved by Kildare County Council, on the downstream pipe network, as described hereafter.
- Storm water from roads will be collected using a traditional gully and pipe network. There are a number of separate pipe networks proposed around the site. Each storm network will discharge to an underground soakaway system discharging to ground. The infiltration rate at the proposed soakaway locations are considered suitable by the project engineers. he road drainage and overflows from the permeable paving system will discharge directly to ground via an infiltration tank, sized to cater for the 100 year design storm event.
- Storm water from the Cancer Treatment Centre, Magee Square, Creche and the spine road will be managed by means of both infiltration (where suitable) and attenuation with controlled discharge to the public network. The surface water drainage measures for these areas was included in the previous planning application for the Cancer Treatment Centre, reference no. 18149, granted permission by Kildare County Council. The overall proposed peak discharge from the overall site to the downstream public storm network is 2/s.

The variability in recorded infiltration rates across the site suggests that there remains a risk of low level infiltration in areas proposed for infiltration to ground. The proposed system has been designed based on professional judgements by the project Hydrologist/Engineer on review of a Stage 1 site investigation. A Stage 2 site investigation (to Eurocode 7) will be required in advance of the final detailed design of the infiltration system to ensure this infiltration rate is representative of the conditions at final formation level at particular areas across the site.

In relation to the overall area of the site i.e. approximately 11 hectares, the total area of hardstanding of the proposed development is approximately 5.82 hectares representing 53.7% of the total area of the Phase 1 site. The site in its current condition has at least 5.0 hectares of hardstanding where runoff predominantly discharges to an existing drainage system on site and the remainder of the site naturally infiltrating to ground. Therefore, based on the above proposed drainage system for the development, it is not anticipated that there will be a significant net reduction of effective recharge to the underlying aquifer.

9.6 PROPOSED FOUL DRAINAGE

There are a number of existing sewers traversing the site which will be diverted into the proposed foul drainage system for the Phase 1 site. It is proposed to provide two new gravity sewer systems – a northern and a southern system – on the Phase 1 site. The southern system will discharge to the existing foul sewer on Hospital Street and the northern system will discharge to the existing 600 diameter foul sewer at the eastern boundary in adjacent Ruanbeg Housing Estate. No foul water discharge to ground is proposed.

9.7 POTENTIAL IMPACT OF THE PROPOSED DEVELOPMENT

The significance of potential impacts on the hydrogeological and hydrological receptors was estimated by implementing a *Design Manual for Roads and Bridges (*DMRB) and IGI Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statements (2013) style of assessment using hydrogeological type attributes and measures to determine the magnitude of the impact on the attribute.

Table 9.4 illustrates the criteria for determining the importance of the sensitive receptors identified at the site, Table 9.5 demonstrates the criteria for estimating the magnitude of the impact on an attribute and Table 9.6 presents the resulting estimation of significant potential impacts.

Importance	Criterion	Typical Examples
Very High	Attribute has a high quality and rarity on regional or national scale.	River, wetland or surface water or groundwater body ecosystem protected by EU legislation. Aquifer providing a regionally important drinking water resource or supporting site protected under wildlife legislation.
High	Attribute has a high quality and rarity on local scale.	Aquifer providing locally important resource or supporting peat ecosystem – undesignated.
Medium	Attribute has a medium quality and rarity on local scale.	Aquifer providing water for agricultural or industrial use with limited connection to surface water. Eroding bog.
Low	Attribute has a low quality and rarity on local scale.	Non-aquifer. Cutover blanket bog.

Table 9.4: Estimation of Importance of Sensitive Attributes

Magnitude	Criterion	Typical Example
Major Adverse	Results in loss of attribute and/or quality and integrity of attribute. Severe.	Loss of aquifer water supply by dewatering or major contamination event. Potential high risk of pollution to groundwater from routine run-off.
Moderate Adverse	Results in effect on integrity of attribute, or loss of part of attribute. Major.	Partial loss or change to aquifer characteristics. Potential medium risk of pollution to groundwater from routine run-off. Loss in peat margins or loss in recharge to a potential SAC Annex 1 habitat.

Magnitude	Criterion	Typical Example
Minor Adverse	Results in some measurable change in attributes quality or vulnerability. Minor.	Potential low risk of pollution to groundwater from routine run-off. Risk of pollution from accidental spillages. Localised peat extraction on bog.
Negligible	Results in effect on attribute, but of insufficient magnitude to affect the use or integrity. Not significant.	No measurable impact upon aquifer and no perceivable risk of pollution from accidental spillages. Slight impact on peat by animal hoofs etc.
Minor Beneficial	Results in some beneficial effect on attribute or a reduced risk of negative effect occurring.	Insignificant risk of contamination to groundwater due to surface sealing.

Table 9.5: Estimation of the Magnitude of a Potential Impact on an Attribute

A qualitative approach was used in this evaluation, generally following the significance classification in Table 9.6 and through professional judgement. The significance of a predicted impact is based on a combination of the sensitivity or importance of the attribute and the predicted magnitude of any effect.

Importance of Attribute	Magnitude of Potential Impact			
	Negligible	Minor Adverse	Moderate Adverse	Major Adverse
Extremely High	Imperceptible	Significant	Profound	Profound
Very high	Imperceptible	Significant / Moderate	Profound/ Significant	Very Large
High	Imperceptible	Moderate / Slight	Significant/ Moderate	Profound/Significant
Medium	Imperceptible	Slight	Moderate	Significant
Low	Imperceptible	Imperceptible	Slight	Slight / Moderate

Table 9.6: Estimation of the Significance of Potential Impact

The prediction of potential impacts from the proposed development are summarised in the following tables, using the headings discussed under the criteria for determination of impacts. The impacts are separated into construction stage impacts and operational stage impacts.

Terms relating to the duration of impacts are as described in the EPA's Guidelines on the Information to be contained in Environmental Impact Statements (March 2002) as:

- Temporary Impact - lasting one year or less;
- Short term Impact - lasting one to seven years;
- Medium term Impact - lasting seven to fifteen years;
- Long term Impact - lasting fifteen to sixty years; and
- Permanent Impact - lasting over sixty years.

9.8 POTENTIAL CUMULATIVE IMPACTS

Given the scale of the proposed mixed-use development and the capacity of the surrounding environment to accommodate a development of this nature and size, it is considered that the overall cumulative Masterplan development will have a slight and long term impact on the underlying groundwater body, through the construction of additional buildings, infrastructure and hardstanding required for a mixed-use development Potential impacts on groundwater quality from untreated stormwater runoff and potential locations of buried waste or contaminated subsoils across and in proximity to the Phase 1 site are considered in addition to potentially reduced rainfall infiltration/recharge to groundwater from low permeability hardstanding areas. However, provided sufficient mitigation

measures are in place, as required under this EIAR, the overall impact on groundwater will be imperceptible.

9.9 'DO-NOTHING' IMPACTS

If the proposed development did not proceed, based on existing site investigation data to-date, there would be no impact on the underlying aquifer. It is envisaged that the land use would remain unchanged as derelict military barracks. However, given the historic use of the site as a former hospital and a former military barracks, a number of potential sources of contamination relating to buried waste material or other contamination-generating sources (e.g. fuel storage, artillery waste material or buried waste material) could be potentially present at the site that could pose a long term and significant impact to groundwater.

9.10 POTENTIAL IMPACTS RISKS

Tables 9.7 and Table 9.8 outline the range of potential impacts associated with the construction and operational phases of the proposed development.

Activity No.	Construction Activity	Attribute	Character of Potential Impact	Importance of Attribute (see Table 9.4)	Magnitude of Potential Impact (see Table 9.5)	Significance of Potential Impact (see Table 9.6)
1	Excavation Activities	Groundwater Surface Water	The removal of topsoil and localised excavations (including the proposed basement carpark under the apartment blocks) across the site will potentially increase the vulnerability of the underlying groundwater aquifer. However, given the high vulnerability rating for the site, as mapped by the GSI, in accordance with Table 9.1, the vulnerability status of the site will not increase to a higher vulnerability status. The risk to the Tully stream is considered to be imperceptible given the distance from the site i.e. 2.5km to the south.	Very High	Negligible	Imperceptible
2	Excavation Dewatering Works	Groundwater Surface Water	It is anticipated that the development site works and excavation proposals (including basement carpark) will not be deep enough to intersect the underlying gravel aquifer during the construction phase. Therefore low level localised dewatering is anticipated resultant from rainfall ingress into excavations and groundwater seepages from locally perched water within localised shallow sand and gravel horizons. The impact on the regional groundwater body is considered to be imperceptible. No impact on the Tully stream is anticipated and therefore the risk is considered to be imperceptible.	Very High	Negligible	Imperceptible
3	Fuel storage/usage on site	Groundwater	Accidental spillage of contaminants during construction works may cause short to long term, moderate to significant impacts to soils and groundwater if not stored and used in a an environmentally safe manner.	Very High	Moderate Adverse	Profound/ Significant
4		Pollardstown Fen	As detailed in Section 9.3.14, the proposed site is not located within the groundwater catchment of Pollardstown Fen with regional groundwater determined to be flowing on a southwesterly direction. Therefore the risk posed to this very sensitive habitat is considered to be imperceptible.	Very High	Negligible	Imperceptible

Activity No.	Construction Activity	Attribute	Character of Potential Impact	Importance of Attribute (see Table 9.4)	Magnitude of Potential Impact (see Table 9.5)	Significance of Potential Impact (see Table 9.6)
5		Surface Water	The Tully stream is located approximately 2.5km south of the site which minimises the risk posed in the event of a fuel spill on the site. However taking a precautionary and conservative approach, the risk is considered to be Moderate to Significant.	Very High	Minor Adverse	Significant/ Moderate
6	Waste Arisings	Groundwater	Contaminated waste material generated from construction activities may require disposal off-site if not suitable for reuse on site. Temporary storage on site may be required and impacts to exposed groundwater from direct runoff during rainfall events may occur.	Very High	Minor Adverse	Significant / Moderate
7	Contaminated land/buried waste	Groundwater	Disturbance and release of potential pollutants within the subsurface during site works. Although contaminated land or illegally deposited waste material has not been encountered across the Phase 1 footprint during previous investigations, there exists a residual risk of encountering unexpected contamination or waste material within particular locations e.g. potential waste within the former gravel quarry, potential former artillery buried waste or unexploded ordnance locations, former fuel storage locations and potential historical hospital waste burial areas. In addition, without further assessment of the made ground/Construction & Demolition waste material identified to the southeast of the site (outside the proposed development site boundary) a conservative approach would be to assume potential risks exist to future site users and to the environment until confirmed otherwise.	Very High	Moderate Adverse	Profound/ Significant
8		Pollardstown Fen	As detailed in Section 9.3.14, the proposed site is not located within the groundwater catchment of Pollardstown Fen with regional groundwater determined to be flowing on a southwesterly direction. Therefore the risk posed to this very sensitive habitat is considered to be imperceptible.	Very High	Negligible	Imperceptible

Activity No.	Construction Activity	Attribute	Character of Potential Impact	Importance of Attribute (see Table 9.4)	Magnitude of Potential Impact (see Table 9.5)	Significance of Potential Impact (see Table 9.6)
9		Surface Water	The Tully stream is located approximately 2.5km south of the site which minimises the risk posed by any potential buried waste or contaminated material within the subsurface when disturbed by construction works. However taking a precautionary and conservative approach, the risk is considered to be Moderate to Significant until confirmed otherwise.	Very High	Minor Adverse	Significant / Moderate
10	Vandalism	Groundwater	Pollution due to vandalism of stores or plant poses a risk to soils and to groundwater and to a lesser extent surface waters.	Very High	Moderate Adverse	Profound/ Significant
11		Surface Water		Very High	Minor Adverse	Significant / Moderate
12	Contaminated imported fill	Groundwater & Surface Water	The importation of unsuitable or contaminated fill material for the purpose of reinstatement works or access road may also pose a risk to the underlying groundwater body and subsequently to downgradient surface water features.	Very High	Moderate Adverse	Profound/ Significant
13	Concrete Wash Water	Groundwater	It is not anticipate that significant concrete wash water will be generated on site. However, inappropriate disposal or uncontrolled runoff of wash water from concrete trucks or wash down facilities has the potential to impact on the quality of the underlying aquifer.	Very High	Minor Adverse	Significant / Moderate

Table 9.7: Potential Impacts during Construction Phase

Activity No.	Construction Activity	Attribute	Character of Potential Impact	Importance of Attribute (see Table 9.4)	Magnitude of Potential Impact (see Table 9.5)	Significance of Potential Impact (see Table 9.6)
1	Hydrocarbon laden surface water runoff from roads, carparks and general hardstanding	Groundwater	Road surface runoff and poorly designed drainage system being directly channelled to groundwater can result in contamination of the groundwater aquifer. Accidental spillages could contaminate the aquifer by direct percolation or via the superficial water network.	Very High	Minor Adverse	Significant
2		Pollardstown Fen	As detailed in Section 9.3.14, the proposed site is not located within the groundwater catchment of Pollardstown Fen with regional groundwater determined to be flowing on a southwesterly direction. Therefore the risk posed to this very sensitive habitat is considered to be imperceptible.	Very High	Negligible	Imperceptible
3		Surface Water	The risk posed to the Tully stream by a poorly designed drainage system is considered to be notably lower with an imperceptible impact considered likely.	Very High	Negligible	Imperceptible
4	Reduced infiltration of rainwater to the underlying aquifer	Groundwater	The increased presence of hard standing across a large area will potentially reduce the amount of infiltration of rainwater to the underlying aquifer and potential impact on the hydrogeological regime and sensitive downgradient receptors.	Very High	Minor Adverse	Significant
5		Pollardstown Fen	As detailed in Section 9.3.14, the proposed site is not located within the groundwater catchment of Pollardstown Fen with regional groundwater determined to be flowing on a southwesterly direction. Therefore the risk posed to this very sensitive habitat is considered to be imperceptible	Very High	Negligible	Imperceptible
6		Surface Water	The risk posed to the Tully stream by reduced rainfall recharge across the Phase 1 site is not considered likely to pose a risk to the stream given the distance from the site.	Very High	Negligible	Imperceptible

Activity No.	Construction Activity	Attribute	Character of Potential Impact	Importance of Attribute (see Table 9.4)	Magnitude of Potential Impact (see Table 9.5)	Significance of Potential Impact (see Table 9.6)
7	Wastewater Disposal	Groundwater Surface water	All foul water is proposed to be discharged to mains sewer network with no discharge to groundwater proposed.	Very High	Negligible	Imperceptible
8	Contaminated land / waste	Groundwater Future Site Users Surface Water	Localised buried made ground material (possibly historical C&D waste) comprising brown sandy gravelly silty clay with significant quantities of brick, timber, glass and metal to depths up to 8.3 mbgl was encountered in the southwestern region of the overall masterplan and outside the boundary of this Phase 1 site. No testing of this material has been undertaken to-date although visual observations did not record any leaching effects, odours, contaminant staining or visual evidence of active contamination in this location. The disturbance and release of pollutants during excavation works in this area is considered a possibility that may pose a long term risk to groundwater or future/adjacent site users without a more detailed investigation in this area of the site.	Very High	Minor Adverse	Significant / Moderate
9		Pollardstown Fen	As detailed in Section 9.3.14, the proposed development is not located within the groundwater catchment of Pollardstown Fen with regional groundwater determined to be flowing on a southwesterly direction. Therefore the risk posed to this very sensitive habitat is considered to be imperceptible.	Very High	Negligible	Imperceptible
10	Basement Carpark	Groundwater Flow	As the proposed basement carpark is proposed at a level approximately 5 metres above the regional sand and gravel aquifer, it is not anticipated to effect groundwater flows across the site.	Very High	Negligible	Imperceptible

Table 9.8: Potential Operational Impacts

9.11 AVOIDANCE, REMEDIAL & MITIGATION

The significant predicted impacts detailed under Tables 9.7 and 9.8 are resolved under the mitigation measures set out within Table 9.9 and Table 9.10. Impacts considered to be imperceptible within Tables 9.7 and 9.8 are not considered further. There are no anticipated residual impacts on the hydrogeological or hydrological environments as a result of the proposed development assuming the stated mitigation measures are implemented.

The following mitigation measures are required for Phase I proposed development site:

Water Mitigation Measures

- Waste fuels and materials shall be stored in designated areas that are isolated from surface water drains or open waters (*e.g.* excavations). Skips will be closed or covered to prevent materials being blown or washed away and to reduce the likelihood of contaminated water leakage. Hazardous wastes such as waste oil, chemicals and preservatives, will be stored in sealed containers and kept separate from other waste materials while awaiting collection by a registered waste carrier. Fuelling, lubrication and storage areas and site offices will not be located within 25m of drainage ditches, surface waters or open excavations. Fuel interceptor tanks will be installed on the site to treat any runoff.
- Back-up plans to deal with the possibility of contamination or fuel spills, *e.g.* pumping of wells or sumps to collect contaminated groundwater for treatment shall be undertaken and included in an overall Construction & Demolition Waste Management Plan (C&DWMP) and Emergency Operation Plan (EOP).
- Special environmental and human health contingency plans and procedures, following best-practice guidance, shall be developed for the unexpected discovery of contaminated or illegally deposited waste materials. These may include a detailed environmental site investigation, contamination delineation, risk assessment and appropriate remediation under the design and supervision of an experienced contaminated land engineer/hydrogeologist.
- A number of potential sources of buried waste/contamination were identified that warrants further consideration as part of any redevelopment works for the site. These include a former gravel pit, a former well, and earthen embankments with C&D waste material evident. These areas will be investigated prior to the commencement of the redevelopment activities and suitable mitigation measures implemented under the direction of a contaminated land consultant/hydrogeologist.
- Monitoring prior to, during and post construction works of surface water and groundwater quality shall be undertaken to ensure minimum disturbance of water quality in the general vicinity of the site. During the construction phase, the monitoring programme will include daily checks, weekly inspections and monthly audits to ensure compliance with the Construction Environmental Management Plan. This will be undertaken in consultation with the wishes of Kildare County Council.
- All waste containers (including all ancillary equipment such as vent pipes and refuelling hoses) shall be stored within a secondary containment system (*e.g.* a bund for static tanks or a drip tray for mobile stores and drums). The bunds shall be capable of storing 110% of the tank capacity. Where more than one tank is stored, the bund shall be capable of holding 110% of the largest tank of 25% of the aggregate capacity (whichever is greater). Drip trays used for drum storage shall be capable of holding at least 25% of the drum capacity. Where more than one drum is stored the drip tray shall be capable of holding 25% of the aggregate capacity of the drums stored.
- Soil removal during the construction phase of the project will be an unavoidable consequence of the development and would apply for virtually any form of site redevelopment. Where possible the soils shall be reused on site.

- Chemical analysis will be carried out to assess whether the made ground or fill material presents a risk to human and/or environmental receptors and to determine a suitable on-site or off-site disposal routes.
- All waste material (both soils and other) generated will be temporarily stored in secure bunded areas thereby preventing the migration of leachate or contaminating substances from impacting on the surrounding environment.
- All imported fill material will be sourced from approved and licenced/permitted facilities. All fill material will be confirmed to be inert prior to importation to the site including confirmation of the chemical testing and a visual assessment.
- Adequate security measures shall be installed on the construction site. Early assessment of the sensitivity of the project and identifying potential locations at risk will assist in the design of the site layout and security measures required. Security measures will include secure fencing, secure site access, securing site plant and equipment, secure storage of materials, sufficient warning signage, and security lighting.
- An appropriately designed drainage system has been incorporated into the design of the proposed development. The system has been designed in accordance with accordance with the Greater Dublin Strategic Drainage Study (GDSDS), the CIRIA SUDS Manual 2015 and Recommendations for Site Development Works for Housing Areas published by the Department of the Environment and Local Government. It involves ensuring that no reduction infiltration to groundwater will incur relative current site conditions and suitable protection measures of runoff infiltration to ground including permeable paving, gullies and catch pits, lined attenuation structures and oil-water interceptors.

Activity No.	Construction Activity	Attribute	Character of Impact	Mitigation	Residual Impact
3	Fuel storage/usage on site	Groundwater	Accidental spillage of contaminants during construction works may cause short to long term, moderate to significant impacts to soil, and groundwater if not stored and used in a an environmentally safe manner.	• Waste fuels and materials will be stored in designated areas that are isolated from surface water drains or open waters (*e.g.* excavations). Skips will be closed or covered to prevent materials being blown or washed away and to reduce the likelihood of contaminated water leakage. Hazardous wastes such as waste oil, chemicals and preservatives, will be stored in sealed containers and kept separate from other waste materials while awaiting collection by a registered waste carrier. Fuelling, lubrication and storage areas and site offices will not be located within 25m of drainage ditches, surface waters or open excavations. Fuel interceptor tanks will be installed on the site to treat any runoff. • All waste containers (including all ancillary equipment such as vent pipes and refuelling hoses) will be stored within a secondary containment system (*e.g.* a bund for static tanks or a drip tray for mobile stores and drums). The bunds will be capable of storing 110% of the tank capacity. Where more than one tank is stored, the bund must be capable of holding 110% of the largest tank of 25% of the aggregate capacity (whichever is greater). Drip trays used for drum storage must be capable of holding at least 25% of the drum capacity. Where more than one drum is stored the drip tray must be capable of holding 25% of the aggregate capacity of the drums stored. • Back-up plans to deal with the possibility of contamination or fuel spills, *e.g.* pumping of wells or sumps to collect contaminated groundwater for treatment shall be undertaken and included in an overall Construction & Demolition Waste Management Plan (C&DWMP) and Emergency Operation Plan (EOP).	Imperceptible
5		Surface water	The Tully stream is located approximately 2.5km south of the site which minimises the risk posed in the event of a fuel spill on the site. However taking a precautionary and conservative approach, the risk is considered to be Moderate to Significant.		Imperceptible

Activity No.	Construction Activity	Attribute	Character of Impact	Mitigation	Residual Impact
				• Monitoring prior to, during and post construction works of surface water and groundwater quality shall be undertaken to ensure minimum disturbance of water quality in the general vicinity of the site. During the construction phase, the monitoring programme will include daily checks, weekly inspections and monthly audits to ensure compliance with the Construction Environmental Management Plan. This will be undertaken in consultation with the wishes of Kildare County Council.	
6	Waste Arisings	Groundwater	Waste material generated from construction activities may require disposal off-site if not suitable for reuse on site. Temporary storage on site may be required and impacts to exposed groundwater and surface waters from direct runoff during rainfall events may occur.	• Soil removal during the construction phase of the project will be an unavoidable consequence of the development and would apply for virtually any form of site redevelopment. Where possible the soils will be reused on site. • Chemical analysis will be carried out to assess whether the made ground or fill material presents a risk to human and/or environmental receptors and to determine a suitable on-site or off-site disposal routes. • All waste material (both soils and other) generated will be temporarily stored in secure bunded areas thereby preventing the migration of leachate or contaminating substances from impacting on the surrounding environment.	Imperceptible
7	Contaminated land/buried waste	Groundwater	Disturbance and release of potential pollutants within the subsurface during site works. Although contaminated land or illegally deposited waste material has not been encountered across the Phase 1 footprint during previous investigations, there exists a residual risk of encountering unexpected contamination or waste material within particular	• A predevelopment site investigation will be undertaken to assess the identified potential sources of contamination and will include additional trial pitting, borehole drilling, soil and water sampling and a geophysical survey in the areas of possible buried ammunitions. • Special environmental and human health contingency plans and procedures, following best-	Imperceptible

Activity No.	Construction Activity	Attribute	Character of Impact	Mitigation	Residual Impact
			locations e.g. potential waste within the former gravel quarry, potential former artillery buried waste or unexploded ordnance locations, former fuel storage locations and potential historical hospital waste burial areas. In addition, without further assessment of the made ground/Construction & Demolition waste material identified to the southeast of the former barracks site (outside the proposed development site boundary) a conservative approach would be to assume potential risks exist to future site users and to the environment until confirmed otherwise.	practice guidance, shall be developed for the unexpected discovery of contaminated or illegally deposited waste materials. These may include detailed site investigation, contamination delineation, risk assessment and appropriate remediation under the design and supervision of an experienced contaminated land engineer/hydrogeologist. • A number of potential sources of buried waste/contamination were identified that warrants further consideration as part of any redevelopment works for the site. These include a former gravel pit, a former well, earthen embankments with C&D waste material evident, former fuel and artillery storage areas. In addition, asbestos within the existing made ground material across much of the site should be considered a possibility without more detailed site investigation information. These areas will be investigated prior to the commencement of the redevelopment activities and suitable mitigation measures implemented as part of a detailed risk assessment under the direction of a contaminated land consultant/hydrogeologist. • A detailed asbestos survey shall be undertaken within all above ground structures and any asbestos identified shall be appropriately removed for off-site disposal by a licensed asbestos removal specialist contractor and validation of the removal certified prior to the commencement of site demolition works. • Excavated materials shall be visually assessed for signs of contamination. Should material appear to be contaminated or potentially contaminated, soil samples shall be analysed by an appropriate accredited laboratory. Contaminated material shall be treated in accordance with the Waste Management Regulations.	
9		Surface Water	The Tully stream is located approximately 2.5km south of the site which minimises the risk posed by any potential buried waste or contaminated material within the subsurface when disturbed by construction works. However taking a precautionary and conservative approach, the risk is considered to be Moderate to Significant until confirmed otherwise.		Imperceptible

Activity No.	Construction Activity	Attribute	Character of Impact	Mitigation	Residual Impact
				• All excess fill and material considered unacceptable for reuse on site in terms of the residual risk posed to human health and to the environment shall be appropriately remediated in accordance with the relevant Waste Management Regulations.	
10	Vandalism	Groundwater	Pollution due to vandalism of stores or plant poses a risk to soils and groundwater.	• Adequate security measures shall be installed on the construction site. Early assessment of the sensitivity of the project and identifying potential locations at risk will assist in the design of the site layout and security measures required. Security measures will include secure fencing, secure site access, securing site plant and equipment, secure storage of materials, sufficient warning signage, and security lighting.	Imperceptible
11		Surface Water			Imperceptible
12	Contaminated imported fill	Groundwater & Surface Water	The importation of unsuitable or contaminated fill material for the purpose of reinstatement works or access road may also pose a risk to the underlying groundwater body and subsequently to downgradient surface water features.	• All imported soils and stones shall be sourced from a licenced/permitted facility with suitable documentation to confirm the material is inert and fit for purpose. The contractor shall satisfy themselves that the material is fit for use before importing to the site.	Imperceptible
13	Concrete Wash Water	Groundwater	It is not anticipate that significant concrete wash water will be generated on site. However, inappropriate disposal or uncontrolled runoff of wash water from concrete trucks or wash down facilities has the potential to impact on the quality of the underlying aquifer.	• All grout/concrete washout facilities will be established away from exposed excavations and into dedicated skips on site. The activities will be monitored and the skips will be appropriately located and secured. • In the event of a major spillage the contractor's Emergency Operating Plan (EOP) will be followed. The first action is to stop the source of pollution and contain the spillage.	Imperceptible

Table 9.9: Construction Mitigation Measures

Activity No.	Activity	Attribute	Character of Impact	Mitigation	Residual Impact
1	Hydrocarbon laden surface water runoff from roads, carparks and general hard standing	Groundwater	Road surface runoff and poorly designed drainage system being directly channelled to groundwater in contact with the aquifer can result in contamination of the groundwater aquifer. Accidental spillages could contaminate the aquifer by direct percolation or via the superficial water network.	• An appropriately designed drainage system has been incorporated into the design of the proposed development. The system has been designed in accordance with accordance with the Greater Dublin Strategic Drainage Study (GDSDS), the CIRIA SUDS Manual 2015 and Recommendations for Site Development Works for Housing Areas published by the Department of the Environment and Local Government. • The system will comprise a number of levels of protection comprising a combination of gullies, catch pits, oil-water interceptors, lined infiltration trenches/galleries and permeable paving and has been designed based on site-specific ground investigations across the site. In addition, it is expected that groundwater is present at depths greater than 7 mbgl which ensures a significant natural filtration layer above the sand and gravel aquifer. The levels of protection designed are considered best practice and will provide a suitable level of protection to the underlying aquifer. • Storm water from all roofs and parking areas will discharge directly into permeable paving systems with stone below to provide quality control and some limited local storage. A permeable membrane is proposed to allow for maximum infiltration to ground. Should the sub soil present be saturated or insufficient to allow infiltration to ground, the system would act as a temporary “tank” and discharge to the internal surface water network until such time that infiltration is possible again. Outflows from permeable paving areas will be via “fin drains” and 110mm outfall pipes to the adjacent storm network. Attenuation up to the 100 year RP design storm event will be provided via underground soakaway systems, Wavin AquaCell infiltration units or similar approved by Kildare	Imperceptible

				County Council, on the downstream pipe network, as described hereafter. • Storm water from roads will be collected using a traditional gully and pipe network. There are a number of separate pipe networks proposed around the site. Each storm network will discharge to an underground soakaway system discharging to ground. The infiltration rate at the proposed soakaway locations are considered suitable by the project engineers. he road drainage and overflows from the permeable paving system will discharge directly to ground via an infiltration tank, sized to cater for the 100 year design storm event. • Storm water from the Cancer Treatment Centre, Magee Square, Creche and the spine road will be managed by means of both infiltration (where suitable) and attenuation with controlled discharge to the public network. The surface water drainage measures for these areas was included in the previous planning application for the Cancer Treatment Centre, reference no. 18149, granted permission by Kildare County Council. The overall proposed peak discharge from the overall site to the downstream public storm network is 2/s. • The variability in recorded infiltration rates across the site suggests that there remains a risk of low level infiltration in areas proposed for infiltration to ground. The proposed system has been designed based on professional judgements by the project Hydrologist/Engineer on review of a Stage 1 site investigation. A Stage 2 site investigation (to Eurocode 7) will be required in advance of the final detailed design of the infiltration system to ensure this infiltration rate is representative of the conditions at final formation level at particular areas across the site.	

4	Reduced infiltration of rainwater to the underlying aquifer	Groundwater	The increased presence of hard standing across a large area can reduce the amount of infiltration of rainwater to the underlying groundwater aquifer and potential impact on the hydrogeological regime and sensitive downgradient receptors.	• The surface water collection and infiltration system for the entire site has been designed in accordance with the Greater Dublin Strategic Drainage Study (GDSDS), the CIRIA SUDS Manual 2015 and Recommendations for Site Development Works for Housing Areas published by the Department of the Environment and Local Government. • In relation to the overall area of the site i.e. approximately 11 hectares, the total area of hardstanding of the proposed development is approximately 5.82 hectares representing 53.7% of the total area of the Phase 1 site. The site in its current condition has at least 5.0 hectares of hardstanding where runoff predominantly discharges to an existing drainage system on site and the remainder of the site naturally infiltrating to ground. Therefore based on the above proposed drainage system for the development, it is not anticipated that there will be a significant net reduction of effective recharge to the underlying aquifer.	Imperceptible
8	Contaminated land / waste	Subsoils / Groundwater /Future Site Users	Localised buried made ground material (possibly historical C&D waste) comprising brown sandy gravelly silty clay with significant quantities of brick, timber, glass and metal to depths up to 8.3 mbgl were encountered in the southwestern region of the overall masterplan and outside the boundary of this Phase 1 site. No testing of this material has been undertaken to-date although visual observations did not record any leaching effects, odours, contaminant staining or visual evidence of active contamination in this location. The disturbance and release of pollutants during excavation works in this area is considered a possibility that may pose a long term risk to groundwater or future/adjacent site users	• A predevelopment site investigation will be undertaken to assess the identified potential sources of contamination and will include additional trial pitting, borehole drilling, soil and water sampling and a geophysical survey in the areas of possible buried ammunitions. • Special environmental and human health contingency plans and procedures, following best-practice guidance, shall be developed for the unexpected discovery of contaminated or illegally deposited waste materials. These may include detailed site investigation, contamination delineation, risk assessment and appropriate remediation under the design and supervision of an experienced contaminated land engineer/hydrogeologist.	Imperceptible

			without a more detailed investigation in this area of the site.		

Table 9.10: Operational Mitigation Measures

9.12 PREDICTED IMPACTS

The nature of the development dictates that the greatest potential impact on the underlying hydrogeology associated with the proposed development will be in the operational phase. It is predicted that the impacts to the hydrogeological and hydrological environments associated with the construction phase of the development will be imperceptible and short term.

With regard to the operational phase of the development, although the discharge of pollutants from runoff to the aquifer could pose a potential risk to groundwater, the proposed drainage system design in conjunction with natural subsoil protection of the sand and gravel aquifer across the site will ensure that no significant impacts on the local hydrogeological geological environment are predicted.

9.13 MONITORING

Site investigations to be undertaken as part of the pre-construction development works will include the installation of boreholes and monitoring wells at the site, soil and groundwater sampling for chemical analysis and the development of a baseline Conceptual Site model of the hydrogeological regime underlying the site. In addition, a groundwater monitoring program comprising groundwater level monitoring and groundwater quality sampling over an extended period of time will be undertaken to confirm baseline hydrogeological conditions across the site and to provide an additional level of protection during the redevelopment works.

9.14 REINSTATEMENT

Typical post construction reinstatement of underground service and drainage trenches after pipe laying, jointing and testing will be undertaken. These reinstatement activities will pose an imperceptible risk

9.15 INTERACTIONS

The potential for interrelationships arises with the environmental topic of biodiversity. Soils, geology and hydrogeology have an important interrelationship with the water and ecological environment, as a determinant of water chemistry, river flow regimes, water storage capacity and watercourse location. It also has an impact on water quality through the ability of bedrock and surface deposits to filter potential pollutants. Potential ecological impacts could occur through the mishandling of soils or through the deposition of excavated soils in ecologically sensitive areas; however the only ecologically sensitive area in proximity to the site is Pollardstown Fen which is not located downgradient of the proposed site or within the groundwater catchment of the site. Any potential impacts have been identified in Section 9.10 and mitigation measures have been proposed in Tables 9.11 and 9.12.

An evaluation was undertaken based on the identification of potential sources, pathways and receptors across the site. If all three elements (source, pathway and receptor) are present, there is a linkage and there is a potential impact to the receptor(s). In terms of groundwater, hydrology and ecology, there are no cSACs or groundwater dependent terrestrial ecosystems (GWDTE) receptors downgradient or in close proximity to the site. Therefore without an environmental receptor being present, the risk is considered to be low. As detailed previously, the site is not located within the groundwater catchment of Pollardstown fen and therefore does not pose a risk to this highly sensitive GWDTE.

During construction the potential impacts to the underlying groundwater aquifer from the proposed works could derive from accidental spillages of fuels or unidentified buried waste material, which could impact on groundwater quality, if allowed to infiltrate to groundwater. As described in Tables 9.9 and 9.10, application of the identified mitigation measures for the predicted impact on the hydrogeological and hydrological environments will ensure that the residual impact, although long-term will be imperceptible.

9.16 DIFFICULTIES ENCOUNTERED IN COMPILING

No particular difficulties were encountered in completing this section.

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Appendix 9.1- NPWS Site Synopsis for Pollardstown Fen SAC

Appendix 9.2 - A summary of E.U. Annex II Habitats and EU Annex IV Species sensitivity to changes in groundwater.

NPWS Site Synopsis for Pollardstown Fen SAC

SITE NAME: POLLARDSTOWN FEN (SITE CODE: 000396)

Pollardstown Fen is situated on the northern margin of the Curragh of Kildare, approximately 3km westnorth- west of Newbridge. It lies in a shallow depression, running in a north-west/south-east direction. About 40 springs provide a continuous supply of water to the Fen. These rise chiefly at its margins, along distinct seepage areas of mineral ground above the Fen level. The continual inflow of calcium-rich water from the Curragh, and from the limestone ground to the north, creates waterlogged conditions which lead to peat formation. There are layers of calcareous marl in this peat, reflecting inundation by calcium-rich water. This peat-marl deposit reaches some 6 m at its deepest point and is underlain by clay.

Pollardstown Fen is unusual in Ireland as it is an extensive area of primary and secondary Fen peat, lacking scrub vegetation on its surface. The Fen vegetation is generally from 0.5 - 1.5 m high and consists mainly of Saw Sedge *(Cladium mariscus),* Reed *(Phragmites australis),* Blunt-flowered Rush *(Juncus subnodulosus)* and a variety of Sedges *(Carex* spp.). The vegetation is quite varied and species-rich with numerous well defined plant communities and several rare or scarce species, including Narrow-leaved Marsh Orchid *(Dactylorhiza traunsteineri),* Fly Orchid *(Ophrys insectifera)* and Broad-leaved Bog Cotton *(Eriophorum latifolium).* Of particular interest is the occurrence of the moss, *Homalothecium nitens* - a boreal relict species which is rare in Ireland. Species and communities characteristic of more nutrient-rich conditions occur on the Fen margins where the water first emerges from the ground, while the central Fen area is dominated by more uniform and less nutrient-demanding vegetation types.

Damp pastures occur on wet mineral soils and partly-drained peats on the Fen margins. These are reasonably species-rich, with particularly good displays of orchids in some areas. The Fen has ornithological importance for both breeding and wintering birds. Little Grebe, Coot, Moorhen, Teal, Mallard, Mute Swan, Water Rail, Snipe, Sedge Warbler and Reed Bunting all breed annually within the Fen vegetation. Reed Warbler and Garganey, both rare breeding species in Ireland, have been recorded at Pollardstown and may have bred. In recent years two very specialised bird species associated with Fens, Marsh Harrier and Savi's Warbler, have been seen at Pollardstown.

An area of reclaimed land was reflooded in 1983 and has now reverted to open water, swamp and regenerating Fen. Since the reflooding of the Fen and the development of the shallow lake, wintering waterfowl have been attracted in increased numbers. Maximum counts during winter 1984/85 were as follows: Little Grebe 24; Teal 161; Mallard 220; Coot 81; Snipe 68.

Otter and Brook Lamprey *(Lampetra planeri),* two species listed in Annex II of the EU Habitats Directive, occur at Pollardstown.

Various groups of the invertebrate fauna have been studied and the system has been shown to support a true Fen fauna. The species complexes represented are often rare in Ireland, with the sub-aquatic organisms particularly well represented. A number of internationally important invertebrates (mostly Order Diptera, i.e. two-winged flies) have been recorded from the site. Of particular conservation importance, however, is the occurrence of all three of the Whorl Snails *(Vertigo* spp.) that are listed on Annex II of the EU Habitats Directive. Pollardstown is the only known site in Ireland (or Europe) to support all three species *(Vertigo geyeri, V. angustior, V. moulinsiana)* and thus provides a unique opportunity to study their different habitat and hydrological requirements.

Much of the Fen vegetation is now owned by the Office of Public Works and is a Statutory Nature Reserve.

Pollardstown Fen is the largest spring-fed Fen in Ireland and has a well developed flora and fauna. Owing to the rarity of this habitat and the numbers of rare organisms found there, the site is rated as of international importance.

E.U. Annex II Habitats and EU Annex IV Species sensitivity to changes in groundwater

Surface water ecosystems and terrestrial ecosystems directly dependent on groundwater. * Indicates priority habitats (after Mayes, 2008)

EU Habitat Code	EU Annex I Habitat	Number of SACs	Type	Sensitivity to changes in Groundwater Quantity	Sensitivity to changes in Groundwater Quality
1150	* Coastal lagoons	25	SW	low - high	Moderate - high
1330	Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)	38	GWDTE	low - moderate	low
1410	Mediterranean salt meadows (*Juncetalia maritimi*)	33	GWDTE	low - moderate	low
2170	Dunes with *Salix repens* ssp. *argentea* (*Salicion arenariae*)	11	GWDTE	high	high
2190	Humid dune slacks	15	GWDTE	high - extreme	high - extreme
21A0	Machairs (* in Ireland)	19	GWDTE	high - extreme	moderate - high
3110	Oligotrophic waters containing very few minerals of sandy plains (*Littorelletalia uniflorae*)	32	SW	moderate	extreme
3130	Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoëto-Nanojuncetea*	9	SW	moderate	high
3140	Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.	18	SW	high	high-extreme
3150	Natural eutrophic lakes with *Magnopotamion* or *Hydrocharition*-type vegetation	9	SW	moderate	moderate
3160	Natural dystrophic lakes and ponds	10	SW	low	extreme
3180	* Turloughs	43	GWDTE	high	moderate - extreme
3260	Watercourses of plain to montane levels with the *Ranunculion fluitantis* and *Callitricho-Batrachion* vegetation	21	SW	moderate	moderate
3270	Rivers with muddy banks with *Chenopodion rubri* p.p. and *Bidention* p.p. vegetation	1	GWDTE	moderate	low
4010	Northern Atlantic wet heaths with *Erica tetralix*	37	GWDTE	low - (extreme)	high
6410	*Molinia* meadows on calcareous, peaty or clayey-silt-laden soils (*Molinion caeruleae*)	13	GWDTE	low - moderate	low - moderate
6430	Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	3	GWDTE	moderate	moderate
7110	* Active raised bogs	51	GWDTE	low - (extreme)**	low -(high)**
7120	Degraded raised bogs still capable of natural regeneration	53	GWDTE	low - (extreme)**	low -(high)**
7130	Blanket bog (* if active bog)	50	GWDTE	low - (extreme)**	low -(high)**
7140	Transition mires and quaking bogs	16	GWDTE	extreme	moderate
7150	Depressions on peat substrates of the *Rhynchosporion*	62	GWDTE	low	moderate
7210	* Calcareous fens with *Cladium mariscus* and species of *Caricion davallianae*	17	GWDTE	extreme	high
7220	* Petrifying springs with tufa formation (*Cratoneurion*)	19	GWDTE	extreme	extreme
7230	Alkaline fens	39	GWDTE	extreme	high
8310	Caves not open to the public	9	GWDTE	extreme	high
91D0	* Bog woodland	11	GWDTE	extreme	low
91E0	*Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-padion, Alnion incanae, Salicion albae*)	23	GWDTE	moderate	low - high

GWDTE – Groundwater Dependent Terrestrial Ecosystem; SW – Surface Water, Aquatic Ecosystem; ** when fen present

GWDTE – Groundwater Dependent Terrestrial Ecosystem; SW – Surface Water, Aquatic Ecosystem; ** when Fen present